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Does cal .22 Improve Marksmanship for Police Students in Sweden?

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Abstract
Firearm training could focus on more practical shooting and tactical training if students pass the examination at an earlier stage during their basic training. The aim of this study is to investigate whether minimizing the recoil, and therefore the startle reaction, and/or psychological factors could increase the shooting scores. This study employs a quasi-experimental design involving two groups of police students: 28 in the control group and 27 in the intervention group. The intervention group received an adjusted version of the Sig Sauer handgun that was changed to fire .22 long rifle caliber ammunition. Although the study group had the best results (86%) over the past fifteen semesters, there was no difference in the shooting performance between the control and the intervention groups, i.e., minimizing recoil in the beginning of the training did not increase the shooting scores. The results of this study indicate that female students with high cognitive anxiety have lower shooting scores than male students with less cognitive anxiety. These findings are discussed with special regard to equalizing any gender differences in firearm training.

Keywords
Cognitive anxiety, firearm examination, gender, police training, startle reaction

1. Introduction
In the Basic Training Program for Police Officers (police program), students learn how to analyze problems, seek knowledge, establish causal relationships, find solutions, make decisions, and evaluate their efforts. Training takes place consistently in an environment in which theory and practice are closely integrated. During their training, students learn the tactical, mental, and communicative skills required to be a professional police officer and how to implement effective methods in practical situations (The Swedish Police Authority, 2018). One part of this is being able to handle firearms in such situations (Morrison, 2003; Morrison, 2006), so it is important that police students learn the right firing technique as early as possible. The first time police students perform the firearm examination is in the third semester of the police program. They have several chances take this examination and most of them eventually pass. Nevertheless, the advantages of passing the firearm examination early are that the firearm training could focus on more practical shooting and tactical training. The psychological well-being of the students should also be prioritized because a failed examination could cause a disturbance in their life planning, such as their economic situation, while also increasing stress and lowering self-esteem. This study was initiated on

the behalf of the firearm teachers at the Police Education Unit at Umeå University, who observed that some of the students had problems with their firing technique, which could be due to startle reaction.

The startle reaction is the extremely rapid (less than one second), psychophysiological response of an organism to a sudden and unexpected stimulus, for example, the recoil and loud sound from a firearm. In human beings, the startle reaction is characterized by spasmodic avoidance movement of the head and involuntary bending of the limbs (Britannica, 2019). The startle reaction is caused by the recoil and loud sound of the firing explosion of the 9 x 19 mm caliber, which often can be perceived as unpleasant. This can lead to the shooter trying to control the firing of the gun by deciding when it should take place or by a jerking of the shot in order to control the reaction to the sound of the firing explosion. Consequently, the grip on the weapon hardens and the shooter does not achieve the desired hit results, even if the barrel-sight-target conditions are ideal.

Recoil is defined as the backward momentum of a weapon when it is fired, which can be categorized as physical and perceived recoil. Morelli et al. (2014) described a methodology for determining the interactive effects of weapon recoil and define perceived recoil as a mental representation of the impact intensity experienced by the shooter – a subjective estimation that encompasses pain, discomfort, propensity to flinch, and other factors. Harper, Ellis, Hanlon, and Merkey (1996) investigated the effects of weapon recoil on aiming accuracy. They stated that weapon recoil forces can be quantified by recording values for impulse, velocity, and energy, with increases in recoil typically associated with degraded shooter performance. They found that the motion caused by recoil results in target point-of-aim deviation within the time interval surrounding the trigger squeeze.

In addition to startle reaction and recoil, individual psychological factors such as personal traits, anxiety states, and personality may have an impact on the shooting performance. For example, Gould et al. (1987) examined relationships between self-confidence and anxiety and shooting performance among police weapon instructors in the US. The findings showed that confidence was negatively related to performance, cognitive anxiety was not related to performance, and somatic anxiety was related to performance in a curvilinear (inverted-U) correlation. We assume that the weapon recoil and/or psychological factors can hamper the learning of right firing technique, and we hope that this original quasi-experimental study can help increase knowledge about how police students learn to shoot, and what factors that imped learning.

2. Aim

The aim of this study is to investigate whether minimizing the recoil, and therefore the startle reaction, and/or psychological factors could increase the shooting scores.

The research questions are as follows:

Q1. Are there any psychological factors that increase or decrease the shooting scores?
Q2. Are there any demographic variables that increase or decrease the shooting scores?

3. Conceptual framework of psychological factors

In the police program, the goal of ensuring better firearm training focuses on factors that can disrupt not only physical performance in a firearm training examination (Anderson & Plecas, 2000), such as grip strength (Copay & Charles, 2001), but also and more often,

psychological performance (Couture et al., 1999; Giessing et al., 2019; Gould et al., 1987; Hashemi et al., 2019; Regehr et al., 2008) such as startle reactions (Barnett et al., 2012).

Schwabe and Wolf (2011) reviewed recent research and found that acute stress caused by glucocorticoids and noradrenergic arousal causes a shift from goal-directed actions towards habits. In the context of shooting, this may mean that students' earlier habits, acquired through regular drills, are superior to what they have learned logically about goal-directed actions. A study conducted among police recruits, using a high-fidelity simulation of a policing event to try to determine performance in a lifelike workplace environment, showed that physiological or psychological reactions did not reduce performance in a simulation of a stressful encounter utilizing the Firearms Training System (FATS). However, police officers with higher than baseline cortisol levels exhibited better shooting performance (Regehr et al., 2008). Conversely, stress could be a positive trait – even a need – for thrill-seekers, as in the case of risk-taking (Zuckerman, 1994). Long-term studies conducted by Marvin Zuckerman indicate that the trait of sensation seeking can motivate people to undertake risky activities. This personality trait has been defined as "seeking varied, novel, complex and intense sensations and experiences and the willingness to take physical, social, legal, and financial risks for the sake of such experience" (Zuckerman, 1994). A police study by Gunnarsson (2012) showed a gender difference in terms of anxiety and self-confidence at the shooting range, where women had lower shooting scores, higher anxiety, and lower self-confidence. This pattern was absent among the men in the study. However, these differences reduced while shooting at laser-simulators. A US study suggests that the police firearm training needs to be evaluated due to the fact that newly-graduated police officers have no advantage over the American intermediate shooters' accuracy (Lewinski et al., 2015).

4. Method

This study took place in 2019 and employed a quasi-experimental design comprising two groups of police students in the third semester: 28 in the control group and 27 in the intervention group. At the beginning of the firearm training, subgroups of 5–7 students were randomly divided into the control and intervention groups.

4.1 Ethical considerations

This study involved no risk of students being injured physically or mentally; the integrity of their data was safeguarded. This study is part of an internal pedagogical development plan, and our intervention included a minor change in the regular basic firearm training process. The students consist of selected healthy individuals who are undergoing the basic training program for police officers. In order to comply with the Swedish Ethical Review Act, Section 3, the students' identities have been replaced with a code. In other respects, this study is not covered by section 4 of the Swedish Ethical Review Act (SFS 2003:460)

4.2 Participants

The study sample comprised 35 men and 20 women, with the mean age of men being 25.5 years and a standard deviation (SD) of 4.4 years. As part of an internal pedagogical development plan, the answering of the questionnaires was done during lecture time, although it was voluntary. This resulted in a good response rate (98.2%) of 55 out of 56 students. The mean age for women was 25.9 years, with an SD of 4.7 years. In total, 43% were living alone and almost all (95%) lived in the same university town. Only 10% of the participants had children. Economic data was not collected.

4.3 Procedure

The intervention group received an adjusted version of the Sig Sauer handgun, which was changed to fire .22 long rifle caliber ammunition. After the fifth lesson, they changed over to a normal version of the 9 mm ammunition gun. The pre-diagnostic firearm lesson one week before the examination was extended for the students to fire as many blanks as they could, with numbers counted and filled in a questionnaire omnibus. The first author met with the students in connection with the firearm lesson and personally informed them about this project and assured them of observing ethical standards to obtain their informed consent. The project was described in a letter, and a paper survey was distributed. A total of 55 police students responded to the survey, and the first author collected the completed questionnaire surveys.

The firearm teachers were briefly educated on basic scientific rules, including observation and documentation of aberrant occurrences that do not normally occur in ordinary weapon education and training. One firearm teacher had the main responsibility for the students in the study and was always present, attentive to the lessons during the time of the study, and mindful of ensuring the students' safety performances.

4.4 The firearm examination

The firearm examination consists of three try-outs with three subtests. The first subtest involved hitting a 25-centimeter (10 inch) target circle from seven meters (23 feet) with five rounds assuming the "readiness position" (gun in hand, aiming to the floor) with two seconds' exposure of the silhouette target board (IPSC).[1] The trialist has a spare magazine with an extra cartridge. The second subtest involves drawing the gun from the holster, hitting a 25-centimeter target circle from seven meters with five rounds and three seconds' exposure of the silhouette target board. The trialist has a spare magazine with an extra cartridge. The third subtest involves precision shooting on high alert with gun cocked and shooting three sequences of five rounds at 90 seconds per sequence from a distance of 20 meters (66 feet). The trialist has a spare magazine with an extra cartridge. After 60 seconds, a signal is sounded indicating that there are 30 seconds left. To pass the examination, the trialist must have a total of 15 shots on the target board and 12 in the target circle. The trialist should demonstrate high security awareness in handling the firearm and be knowledgeable about basic safety rules. The total number of hits in the target for all three try-outs is counted as the shooting score. A hit in the circle counts as two points, a hit on the target as one, and a missed target results in a minus one (minimum -15 points and maximum 90 points). Since all tests are time-limited, malfunction of the pistol gives the trialist a new try-out.

4.5 Measurement instrument and demographic variables

The questionnaire omnibus of instruments included the Competitive State Anxiety Inventory-2 (CSAI-2), which measures personal traits of self-confidence and a bi-dimensional measure of state anxiety. The scale was developed by Rainer Martens and colleagues (1977). The CSAI-2 comprises 27 items that fall under the three subscales of Cognitive Anxiety, Somatic Anxiety, and Self Confidence. The Cronbach's alpha value fell between .85 and .90 for the Swedish translated questionnaire answered by 571 male and 398 female Swedish students (Lundqvist & Hassmén, 2005). The CSAI-2 had minimum and maximum scores of 27 and 108 respectively.

The Zuckerman-Kuhlman Personality Questionnaire (ZKPQ) was developed to identify personality traits that were basic factors influencing temperament. The ZKPQ has 50 items

1. International Practical Shooting Confederations target, classic model.

constructed across five subscales: activity, aggressive/hostile, impulsivity, neuroticism, and sociability (Zuckerman et al., 1991). The Cronbach's alpha value ranged from the lowest (male activity) .62 to .79 (female sociability) in a study of 208 male and 820 female American students (Zuckerman, 2002). Due to the questionnaire, all scales had four responses rated on a Likert-scale ranging from one (*not at all*) to four (*a lot*).

The overall dependent variable in this study was shooting score. The independent variables comprised sex; age; height; weight; hand size; civil firearm training; military firearm training; trigger finger exercise (done or not); version of Sig Sauer (P226, P229, or P239); total number of blank firings; and experience of first-person-shooter PC games. As potential variables of stress, variables such as participants' civil status, children, and whether they were residents in the university town or had to travel were collected. Overall, both the lessons and the firearm examination were executed in the same way as in previous years, according to the police education curriculum. No alterations were made for the study. The project was funded by the Police Education Unit at Umeå University.

4.6 Statistical analysis

All statistical analyses were carried out using IBM SPSS Statistics 26 (SPSS, 2019). The internal reliability of the personal trait scales was calculated using both "Cronbach's alpha" and the "Cronbach's alpha if the item was deleted". If the minimum deleted alpha value deviated from the mean alpha value, the related item was deemed to be a contributor to the scale factor; on the other hand, if the maximum deleted alpha value deviated from the mean alpha value, that item lowered the internal reliability of the scale. Sample description was done of mean, standard deviation (SD) or percentage for the whole study group. The homoscedasticity of each variable was visually checked by observing Q-Q detrended scatterplots of observed values against deviation from normality.

Statistical analysis of the t-tests between the control and intervention groups, on personal variables, experiences that could increase marksmanship and scores on the psychological instruments CSAI-2 and ZKPQ were conducted (Cohen, 1992), and chi^2 tests on nominal data. As we observe the results, we saw that all eight who failed the firearm examination were women. Therefore, we conducted a post-hoc correlation test on all the variables, followed by a t-test and chi^2 on nominal data, of the significant correlated variables between sexes, to determine any differences that might be interesting in the backwards elimination regression. A Pearson correlation matrix was done to determine which variables predict shooting scores, and also to check for multicollinearity; if high correlations were observed, a secondary analysis of tolerance was conducted to detect values beneath .25 that equal an acceptable variance inflation factor beneath four (Norušis, 2012; Menard, 2002).

To prove the post-hoc hypothesis and determine the significant predictors of the shooting scores, a backwards elimination (linear) regression was conducted. Bootstrapping of 1,000 samples was done wherever possible (Field, 2018). The sample size was rather small. This might increase the likelihood of a type II error skewing the results but also decrease the power of the study. In addition, there was no control of the increase in family-wise error rate, like Bonferroni, across the statistical analyses in risk of further increasing the type-II risk (Nakagawa, 2004; Perneger, 1998; Cabin & Mitchell, 2000). In intervention studies that have been designed to test a specific hypothesis such as ours ("Practicing with initial caliber .22 improves marksmanship"), the use of Bonferroni or other false discovery rate correction factors is not necessary (Hoppe et al., 2020).

5. Results

The reliability statistics of the Personality Traits Instruments in the current study is shown in Table 1. Since all subscales had a reasonable variance of alpha value and did not deviate too much from the mean Cronbach's alpha value, we only report the minimal and the maximal values.

Table 1. Scale of internal reliability calculations (N=55)

Sub scales (number of items)	Mean	SD	Cronbachs α	Min del α	Max del α
ZKPQ Activity (10)	25.25	4.77	.82	.79	.83
ZKPQ Aggressive- Hostile (10)	19.25	3.92	.67	.60	.68
ZKPQ Impulsive (10)	20.20	4.17	.67	.60	.69
ZKPQ Neuroticism (10)	16.11	4.44	.83	.80	.83
ZKPQ Social Ability (10)	27.39	4.80	.77	.73	.79
CSAI-II Cognitive Anxiety (9)	19.71	6.39	.92	.90	.92
CSAI-II Somatic Anxiety (9)	17.20	4.00	.74	.65	.86
CSAI-II Self Confidence (9)	23.00	6.36	.93	.92	.94

Min del α = Lowest Cronbach's alpha in the scale if item was tentative deleted.
Max del α = Highest Cronbach's alpha in the scale if item was tentative deleted.

The statistics of students who passed and failed the firearm examinations on the first occasion were collected over a period spanning 7.5 years including 15 semesters (see Figure 1). The overall pass percentages over this period were 72%, including this study. The study group performed (fall 2019) the best results (86%) in the firearm examination over the past 15 semesters.

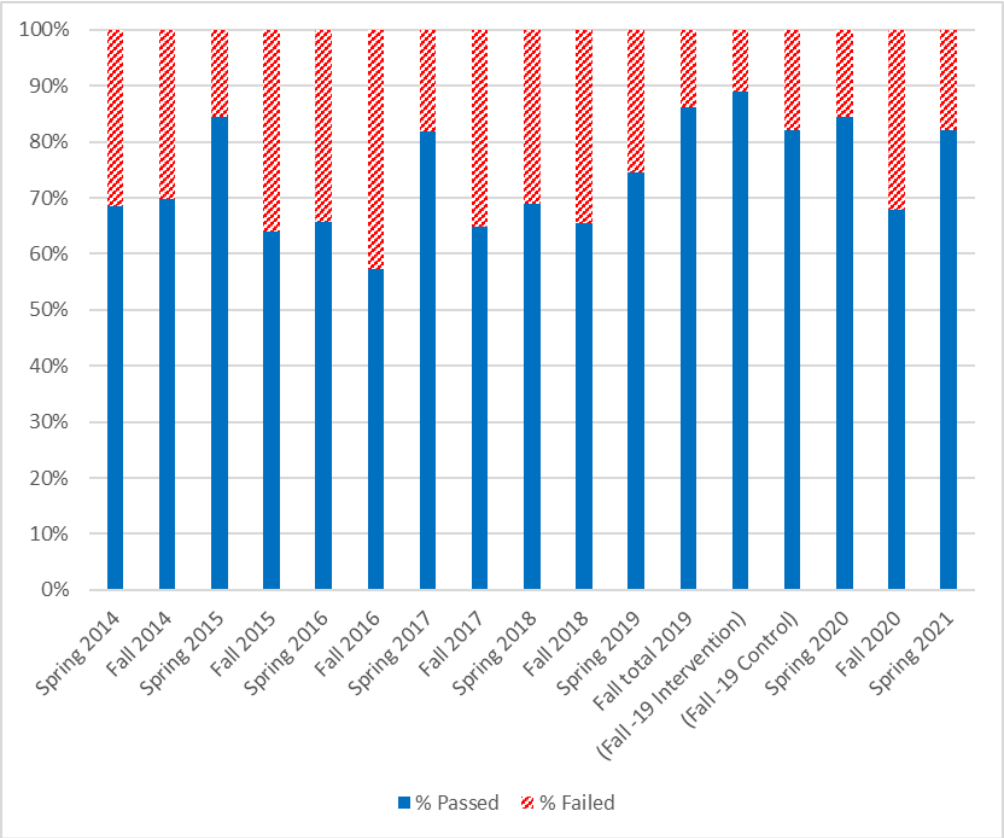

Figure 1. Statistics of students who passed and failed the firearm examinations 2014–2021

The visual control of homoscedasticity of each variable did not show any deviation from normality. Table 2 shows all characteristics of the measured variables. Notable is that the SD is low compared to the mean, which shows a rather homogenous sample, except the variable *Number of blank shots*, where one participant manage to click 435 blanks, almost the double compared to the participant at the second place.

Table 2. Sample description

Variables	%	Mean	SD	Lowest	Highest
Shooting score		78.5	9.7	42	89
Age *(year)*		26.3	4.5	20	42
Height *(cm)*		177.4	10.2	160	201
Weight *(kg)*		81.4	14.0	57	119
Hand size *(perimeter inch)*		7.7	1.6	6	12
Nr of children *(median)*		.18 *(0)*	-	0	3
Nr of blank shots *(median)* [a]		100 *(88)*	61	30	435 [a]
Aggression-Hostility ZKPQ		19.3	3.9	11	32
Impulsive ZKPQ		20.2	4.2	12	30
Neuroticism ZKPQ		16.1	4.4	10	27
Social ZKPQ		27.4	4.8	17	37
Activity ZKPQ		25.3	4.8	16	36
Cognitive-Anxiety CSAI-2		19.7	6.4	9	33
Somatic-Anxiety CSAI-2		17.2	4.0	11	27
Self-Confidence CSAI-2		23.0	6.4	11	36
Group *(Intervention)*	49				
Sex *(male)*	64				
Type of weapon *(P229)*	65				
Civil status *(twosome)*	56				
Resident *(university city)*	95				
Finger- training *(yes)*	25				
Civil weapon training *(yes)*	18				
Military weapon training *(yes)* [a]	29				
PC-games practice *(yes)*	58				

[a] Please note outlier.

With regard to the dependent variable *Shooting score*, the scores from firearm examinations that were passed (mean=81.60, SD=4.34) and failed (mean=60.63, SD=13.19), overlapped with the maximum score of 76 points for those who failed and with a minimum score of 73 points for those who passed; therefore, no threshold score was calculated. The differences in the shooting score were not significant between the intervention group and control group, (t=-.23, [df=53], p=.82). In fact, as shown in Table 3, none of the variables differed significantly, with even the CSAI-2 *Cognitive Anxiety* showing the exact same result in both groups (t=0.0, [df=53], p=.999).

Table 3. Independent t-test and chi² tests between intervention (n=27) and control group (n=28)

Variables	t (Chi²)	df	Sig. (2-tailed)	Mean Difference
Shooting score	-.23	53	.82	-0.60
Age	0.38	53	.70	0.46
Height	-0.65	53	.52	-1.8
Weight	0.34	47	.73	1.4
Hand size	-0.33	52	.75	-0.15
Nr of children	0.42	53	.68	0.07
Nr of blank shots	-1.07	53	.29	-17.5
Aggression-Hostility ZKPQ	0.54	53	.59	0.57
Impulsive ZKPQ	0.09	53	.93	0.1
Neuroticism ZKPQ	0.36	53	.72	0.43
Social ZKPQ	0.61	53	.55	0.78
Activity ZKPQ	.84	53	.41	1.08
Cognitive-Anxiety CSAI-2	0.64	53	.53	1.1
Somatic-Anxiety CSAI-2	0.29	53	.77	0.32
Self-Confidence CSAI-2	0	53	.999	0
Sex*	(0)	1	1	-
Type of weapon*	(3.9)	2	.14	-
Civil status*	(1.6)	4	.81	-
Resident*	(0.35)	1	.55	-
Finger- training*	(0.10)	1	.75	-
Civil weapon training*	(0.13)	1	.71	-
Military weapon training*	(0.84)	1	.36	-
PC-games practice*	(0.72)	1	.40	-

* Chi² test due to nominal data.

There were no significant differences in the t-tests between men and women in the subscales of *ZKPQ-activity*, *ZKPQ-hostile/aggressive*, *ZKPQ-impulsivity*, and *ZKPQ-sociability*; therefore, those ZKPQ subscales were not included in table 4 or in the backwards linear regression. Dependency and multicollinearity are logically between sex and all physical variables including *Type of Weapon*; however, all physical variables had a tolerance over .25 except *Hand Size* (T=.2, VIF=5.01), which was not included in the backwards linear regression. The psychological variables were also correlated to sex, but all had a tolerance over .25.

Table 4. Frequencies, t-tests and chi² tests between men (n=35) and women (n=20) in relation to variables that are significant correlated to sex.

Variable	Female	Male	t-test *(Chi²)*	p-value
	Mean, (SD)			
Score	72 (12.7)	82 (4.36)	4.41	< .001
Height, cm	168.8 (5.6)	182.3 (8.9)	6.07	< .001
Weight, kg	70.7 (7.7)	87 (13.4)	5.40	< .001
Hand Size	6.2	8.7	7.46	< .001
Type of Weapon*	13	22	(18.2)	< .001
Blanks shot (counts)	68 (16,6)	118 (69.5)	2.88	.008
PC-Game Practice (yes)*	2	30	(28.8)	< .001
Civil Weapon Training (yes)*	1	9	(3.4)	.07
Cognitive Anxiety CSAI-2	23.65 (5.91)	17.46 (5.56)	-3.88	< .001
Somatic Anxiety CSAI-2	18.75 (4.10)	16.31 (3.72)	-2.25	.03
Self-Confidence CSAI-2	18.25 (4.30)	25.71 (5.74)	5.05	< .001

* Chi² test due to nominal data.

The variables that had a negative correlation (Table 5) with shooting scores were psychological scales that indicate problems, *Cognitive Anxiety CSAI-2*, *Somatic Anxiety CSAI-2*, and *Neuroticism ZKPQ*. The other dichotomous variables that were positively correlated with shooting scores were being male, bigger hands and weapon, practicing first-person shooting PC games, and experience of weapon training, both civil and military. The strongest correlation was between *Cognitive Anxiety CSAI-2* and *Sex*.

Table 5. Significant correlation between shooting score and independent variables in descending order.

Variable	r	Sig. 2-tail
Cognitive Anxiety CSAI-2	-.54	< .01
Sex	.52	< .01
Self-Confidence CSAI-2	.42	< .01
Neuroticism subscale of ZKPQ	-.36	< .01
Hand Size	.35	< .01
Type of Weapon	.35	< .01
PC-Game Practice	.32	.02
Civil Weapon Training	.32	.02
Somatic Anxiety CSAI-2	-.31	.02
Height in centimeters	.28	.04
Military Weapon Training	.28	.04

Note: N=55 for all variables.

The backwards elimination (linear) regression was based on the correlations in Table 5, except *Hand Size*. The inclusion criteria were a probability of the F-score equal to or smaller than .05. The elimination order was first, *Military Weapon Training*, followed by *Type of Weapon*, *Somatic Anxiety CSAI-2*, *Self -Confidence CSAI-2*, *Civil Weapon Training*, *Height*, *Neuroticism ZKPQ*, and finally *PC Games Practice*. All these variables were non-significant in the regression. The regression results revealed that *CSAI-2 Cognitive Anxiety* and *Sex* were significant predictors (Table 6) and explained 36% of the variation in the regression (adjusted r^2=.35) of the variables accounted for in the shooting scores. Every point of the variable *Cognitive Anxiety CSAI-2* lowered the shooting score (B-value) by .61 points. In contrary, being a male student raised the score by 6 points.

Table 6. Backwards regression on shooting scores

Variable	B	t	Sig. 2-tail	Std. Error
(Constant)	86.92	18.02	<.001	4.82
Cognitive Anxiety CSAI-2	-0.61	-3.26	.002	0.19
Sex	6.06	2.42	.02	2.51

The commonly noted deviance factors were: (a) one student declined to participate in the study and was excluded; (b) to comply with health regulations, the bullets for indoor shooting were required to be non-lead but, after finding a copper bullet, it turned out that its weight was too light for the recoil spring of the cal .22 exchange unit, occasionally causing a failure in automatically pushing the next cartridge in place for firing, so the cocking had to be done by hand; (c) one student woman had very small hands for the size of exchange unit and was moved from intervention to the control group, which increased the equality of variance in sex between the groups.

6. Discussion

The aim of this study was to investigate whether minimizing the recoil, and therefore the startle reaction, and/or psychological factors could increase the shooting scores. Earlier studies have investigated the variables correlated to shooting scores, with mental training and physical factors being the areas of focus. Although training combining biofeedback with relaxation (Couture et al., 1999) showed significant improvements, the physical variables were not included in the study.

The first important finding from the current study is that there was no difference in the shooting performance between the control and the intervention groups, i.e., minimizing recoil in the beginning of the training did not increase the shooting scores. This could be attributed to the small sample size, which increases the likelihood of a type II error skewing the results. Therefore, we suggest future studies with a greater sample size.

With regard to the first research question, the psychological traits in this study were non-significant in the t-test between the control and intervention groups. However, the impact of psychological factors on the shooting score was indicated by the score of the CSAI-2 Cognitive Anxiety subscale, as Gunnarsson's (2012) study also showed. This outcome differs to that of Gould et al. (1987) who found no relationship between cognitive anxiety and shooting performance. However, they found that confidence was negatively related to performance and that somatic anxiety was related to performance in a curvilinear (inverted-U) fashion. Further qualitative research might explore this inconsistency between police students with 2.3 years of pistol shooting experience and police students with zero experience.

With regard to the second research question about differences in the demographic variable, the answer was that the major variable of sex differed between those who failed the examination and those who passed. Due to the small sample size, especially in the group of the eight participants who failed the examination, we cannot rule out coincidence and have to be cautious when interpreting this result. Nevertheless, the shooting score difference (10 points) between women and men is something to reflect upon. These findings will doubtless be heavily scrutinized. Previous studies have also investigated differences between males and females in relation to shooting. For example, a Swedish study conducted by Gunnarsson (2012) similarly reported that male police students perform better than female police students. Anderson and Plecas (2000) conducted a comprehensive study on anthropometric measures and found a 60% difference in handgrip strength between females and males. We found a difference in hand strength, as measured by blank shots (counts), which were 68 (SD=16.6) for women and 118 (SD=69.5) for men, but this difference cannot be verified to have a direct effect on shooting score. The difference between females and males was investigated before and after handgrip training with improvement in shooting scores as target variable (Copay & Charles, 2001). Both sexes showed improvement, but males performed better than females. In addition, the same researchers (Charles & Copay, 2003) investigated a police firearms training course in Illinois in 2002. The females showed greater improvement in marksmanship (75%) than did the men (57%) but did not quite attain the mean scores of the men (M=108.35, F=97.90). However, in that gender-focused study, no psychological variables were included. Further research needs to examine more closely the links between sexes, physical factors (e.g., hand grip strength) and shooting performance.

6.1 Limitations

Despite these valuable findings, our study had several limitations. As mentioned above, a sample size that is small reduces the power of the study and increases the margin of error. The generalizability of our results is subject to certain limitations. For instance, the results

showed differences in gender; however, because we only considered Swedish police students, this finding may not translate to students in other countries. The study is also limited by the lack of previous research on the topic, especially in the Scandinavian context. An additional uncontrolled factor is the possibility that there was a difference between the intervention group and the control group in terms of students' shooting skills before students began their firearm training at the police program. This is difficult to handle because of the safety regulation that prevents students from practicing shooting before the firearm training has started. We are investigating the possibilities of testing students' shootings skills before the training begins using the Firearms Training System (FATS). Nonetheless, in spite of its limitations, this study adds to the understanding of basic firearm training for police students.

7. Conclusion

The results of this study show that female students with high cognitive anxiety have lower shooting scores than male students with less cognitive anxiety. These findings have several important implications for equalizing any gender differences in firearm training. First, based on previous studies and the present study, we suggest that the organization of the male-dominated police training must consider gender differences and cognitive anxiety in establishing a learning environment where the students feel supported and respected. Second, the firearm teachers need to be aware of the variables that correlate to shooting scores so they can take measures to provide the right kind of support. Third, if students pass the examination at an earlier stage, the firearm training during the basic training could focus on more practical shooting and tactical training, which will, in turn, make society safer because the police will be better prepared for, and more capable of, handling firearms in practical situations.

This study left several questions unanswered. Did the students' poor shooting skills cause their anxiety to increase? Did their high anxiety cause their shooting skills to deteriorate? Did the two factors interact so that students' poor shooting skills worsened with high anxiety? These questions should be researched and addressed in future studies. Another point to consider is whether female students are more worried than male students in general and how they are affected by being in an organization dominated by men. The correlation between shooting score and cognitive anxiety among both women and men would be an important topic to investigate further. Further studies that seek to understand the differences between males and females are suggested. In the future, we plan to identify the main factors that can predict success in firearm training for police students during their basic training.

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References

Anderson, G. S. & Plecas, D. B. (2000). Predicting shooting scores from physical performance data. *Policing: An International Journal of Police Strategies & Management*, *23*(4), 525–537. https://doi.org/10.1108/13639510010355611

Barnett, J., Wong, W., Westley, D., Adderley, R., & Smith, M. (2012). Startle reaction: Capturing experiential cues to provide guidelines towards the design of realistic training scenarios. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *56*(1), 2477–2481. SAGE. https://doi.org/10.1177/1071181312561504

Britannica. (2019). *Startle reaction*. https://www.britannica.com/science/startle-reaction.

Cabin, R. J., & Mitchell, R. J. (2000). To Bonferroni or not to Bonferroni: When and how are the questions. *Bulletin of the Ecological Society of America*, *81*(3), 246–248. http://www.jstor.org/stable/20168454

Charles, M. T., & Copay, A. G. (2003). Acquisition of marksmanship and gun handling skills through basic law enforcement training in an American police department. *International Journal of Police Science & Management, 5*(1), 16–30. https://doi.org/10.1350/ijps.5.1.16.11245

Cohen, J., (1992). Statistical power analysis. *Current Directions in Psychological Science*, *1*(3), 98–101. https://doi.org/10.1111/1467-8721.ep10768783

Copay, A. G., & Charles, M. T. (2001). The influence of grip strength on handgun marksmanship in basic law enforcement training. *Policing: An International Journal of Police Strategies & Management*, *24*(1), 32–39.

Couture, R. T., Singh, M., Lee, W., Chahal, P., Wankel, L., Oseen, M., & Wheeler, G. (1999). Can mental training help to improve shooting accuracy? *Policing: An International Journal of Police Strategies & Management*, *22*(4), 696–711. https://doi.org/10.1108/13639519910299607

Field, A. (2018). *Discovering Statistics Using IBM SPSS Statistics*. SAGE.

Giessing, L., Frenkel, M. O., Zinner, C., Rummel, J., Nieuwenhuys, A., Kasperk, C., Brune, M., Engel, F. A., & Plessner, H. (2019). Effects of coping-related traits and psychophysiological stress responses on police recruits' shooting behavior in reality-based scenarios. *Frontiers in Psychology*, *10*, 1523. https://www.doi.org/10.3389/fpsyg.2019.01523

Gould, D., Petlichkoff, L., Simons, J., & Vevera, M. (1987). Relationship between Competitive State Anxiety Inventory-2 subscale scores and pistol shooting performance. *Journal of Sport and Exercise Psychology*, *9*(1), 33–42. https://doi.org/10.1123/jsp.9.1.33

Gunnarsson, J. 2012. Weapon education at Police Academy. PHS-776-5307/10 PHS Serie PHS-776-5307/10. The Police Academy at Soerentorp, Solna, Sweden: Polishögskolan.

Harper, W. H., Ellis, P. H., Hanlon, W. E., & Merkey, R. P. (1996). *The effects of recoil on shooter performance*. No. ARL-TR-382. ARMY Research Lab Aberdeen Proving Ground MD.

Hashemi, M. M., Gladwin, T. E., De Valk, N. M., Zhang, W., Kaldewaij, R., Van Ast, V., Koch, S. B., Klumpers, F., & Roelofs, K. (2019). Neural dynamics of shooting decisions and the switch from freeze to fight. *Scientific Reports*, *9*, 4240. https://doi.org/10.1038/s41598-019-40917-8

Hoppe, M., Ross, A. B., Svelander, C., Sandberg, A. S. & Hulthén, L. (2020). Reply to the comments by Vorland et al. on our paper: "Low-phytate wholegrain bread instead of high-phytate wholegrain bread in a total diet context did not improve iron status of healthy Swedish females: A 12-week, randomized, parallel-design intervention study." *European Journal of Nutrition*, *59*, 2815–2817.

Lewinski, W. J., Avery, R., Dysterheft, J., Dicks, N. D, & Bushey, J. (2015). The real risks during deadly police shootouts: Accuracy of the naive shooter. *International Journal of Police Science & Management, 17*(2), 117–127. https://doi.org/10.1177/1461355715582975

Lundqvist, C., & Hassmén, P. (2005). Competitive State Anxiety Inventory-2 (CSAI-2): Evaluating the Swedish version by confirmatory factor analyses. *Journal of Sports Sciences*, *23*(7), 727–736. https://doi.org/10.1080/02640410400021484

Menard, S. (2002). *Applied Logistic Regression Analysis*. SAGE.

Morelli, F., Neugebauer, J. M., Lafiandra, M. E., Burcham, P., & Gordon, C. T. (2014). Recoil measurement, mitigation techniques, and effects on small arms weapon design and marksmanship performance. *IEEE Transactions on Human-Machine Systems*, *44*(3), 422–428. https://doi.org/10.1109/THMS.2014.2301715

Morrison, G. B. (2003). Police and correctional department firearm training frameworks in Washington State. *Police Quarterly, 6*(2), 192–221. https://doi.org/10.1177/1098611103006002004

Morrison, G. B. (2006). Police department and instructor perspectives on pre-service firearm and deadly force training. *Policing: An International Journal of Police Strategies & Management, 29*(2), 226-245. https://doi.org/10.1108/13639510610667646

Nakagawa, S. (2004). A farewell to Bonferroni: The problems of low statistical power and publication bias. *Behavioral Ecology*, *15*(6), 1044–1045. https://doi.org/10.1093/beheco/arh107

Norušis, M. J. (2012). *IBM SPSS Statistics 19 Statistical Procedures Companion*. Prentice Hall.

Perneger, T. V. (1998). What's wrong with Bonferroni adjustments. *BMJ*, *316*, 1236–1238. https://doi.org/10.1136/bmj.316.7139.1236

Regehr, C., Leblanc, V., Jelley, R. B., & Barath, I. (2008). Acute stress and performance in police recruits. *Stress and Health: Journal of the International Society for the Investigation of Stress*, *24*(4), 295–303. https://doi.org/10.1002/smi.1182

Schwabe, L. & Wolf, O. T. (2011). Stress-induced modulation of instrumental behavior: From goal-directed to habitual control of action. *Behavioural Brain Research*, *219*(2), 321–328. https://doi.org/10.1016/j.bbr.2010.12.038

SFS 2003:460. *The Ethical Review Act.* https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/lag-2003460-om-etikprovning-av-forskning-som_sfs-2003-460

SPSS, I. 2019. *IBM SPSS Statistics for Windows, Version 26.0*. IBM Corp.

The Swedish Police Authority (2018). Training plan for the police program. Diary no. A070.568/2018.

Zuckerman, M. (1994). *Behavioral expressions and biosocial bases of sensation seeking*. Cambridge University Press.

Zuckerman, M. (2002). Zuckerman-Kuhlman personality questionnaire (ZKPQ): An alternative five-factorial model. In: B. D. E. Raad & M. E. Perugini (Eds.) *Big five assessment*. Hogrefe & Huber Publishers.

Zuckerman, M., Kuhlman, D. M., Thornquist, M. & Kiers, H. (1991). Five (or three) robust questionnaire scale factors of personality without culture. *Personality and Individual Differences*, *12*(9), 929–941. https://doi.org/10.1016/0191-8869(91)90182-B