This article was written by Donald Rodd, Ph.D., a professor at the University of Evansville. He and several colleagues were studying the correlation between grip strength and shooting ability as measured by qualification scores. He found such a correlation exists, but it does not progress indefinitely. Curious? Read on to uncover the details.

The Effects of Grip Strength and Firearm Discharge

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Law enforcement officers must possess a number of unique characteristics and skills that are not common in most professions such as the ability to react under pressure and high levels of physical fitness. As a result of these demands, candidates applying for acceptance to law enforcement academies, such as the Indiana Law Enforcement Academy (ILEA), are screened, prior to acceptance, using a battery of oral, physical, psychological and written examinations. The results of the various screening measures are used in part to predict how well candidates will handle the high stress and physical demands of a law enforcement career.

Firearm discharge is a critical element to a police officer's career and one that could potentially save lives. Therefore, firearm training is an important part of the ILEA training program and includes two weeks of handgun and shotgun instruction. ILEA recruits practice and qualify their shooting skills in various positions including standing, half-kneeling and prone. General firearm instructions at the ILEA include loading and unloading firearms, clearing misfires, site line-up and pressure on trigger. After firearm qualifications are completed, tactical scenarios are then enacted that provide the recruits with a more realistic sensation of firearm use. Upon completion of the two week practice and qualification period, over sixteen hundred rounds have been fired. Based

on the common assumptions of strength and accuracy, it is logical to assume that those recruits who possess the highest levels of good grip strength will also exhibit higher levels of marksmanship compared to those with weaker grip strength.

However, a review of the extant literature revealed a paucity studies that examined the relationship between grip strength and firearm discharge. A study published by Charles and Copay in 2003 examined 216 inexperienced shooters and tested their marksmanship consistency in fourteen rounds including loading, unloading and clearing malfunctions. The results demonstrated that recruits significantly improved marksmanship and gun handling skills after attending firearms instruction (Charles and Copay 2003). Copay and Charles (2001) examined the effects of grip strength training on semi-automatic handgun marksmanship in police recruits. Copay and Charles assigned one group to handgrip training using a handgrip dynamometer while the other group did not undergo handgrip training acted as a control. The results of this study indicated improved marksmanship scores for both groups and no difference in marksmanship scores between groups. Thus, handgrip training did not improve shooting scores, and the resulting improvement in overall shooting scores was attributed to marksmanship training (Copay and Charles 2001). However, a study conducted by Anderson and Plecas (2000) used various physical performance measures and anthropometric values to potentially predict marksmanship. The results of this study demonstrated a correlation between marksmanship and grip strength, but no equation to predict shooting scores was formulated (Anderson and Plecas 2000).

Hence, few qualitative studies have been published that have looked at the relationship between grip strength and marksmanship. Moreover, results from these studies have offered conflicting evidence as to the importance of this association. Hence, further research is needed in this area to establish the importance of grip strength to shooting accuracy. Moreover, the development of a prediction equation for shorting accuracy based on handgrip strength would allow law enforcement training programs to devise strength training programs designed to improve marksmanship. Thus, the dual purposes of this study were to determine the relationship between handgrip strength and shooting accuracy in applicants to the ILEA, and to develop a calculation that would allow a prediction of accuracy based on handgrip-strength.

Methodology

Approval for this study was obtained from the University of Evansville's Institutional Review Board for the Protection of the Human Subjects and the Indiana State Police (ISP). The participants consisted of the 67th recruit academy of the Indiana State Police in Plainfield, Indiana. The recruits (N=141) were divided into two platoons and eight squads by the academy staff and range from 21-37 years of age. Grip strength was measured with a Smedley III hand dynamometer (Stoelting Co, Wood Dale, Ill) for dominant and non-dominant hands over 3 consecutive trials on three separate occasions. The first trial was performed, upon entering the ISP academy before the end of week one (Entry-level), the second trial was performed the day prior to their initial firearms training (Prequalifying) and the third trial was done upon completion of their qualification rounds (Post qualifying). Handgrip strength values were compared

using paired t-tests and regression analysis to develop the prediction equations. Data were analyzed using SPSS software for Windows version 12.0 (SPSS Inc., Chicago, IL).

Results

Following 26 weeks of training, a significant increase in dominant & non-dominant handgrip ($P<0.01$) was exhibited by the recruits. However, following 1600 rounds of shooting, dominant handgrip strength revealed a non-significant decrease ($P=0.079$) while non-dominant handgrip strength exhibited no change ($P=0.587$). Although fatigue affects handgrip strength, the small decreases that were detected, did not impact accuracy. Results from this study revealed a positive association between handgrip strength and handgun qualifying score. However, many recruits with high grip strength values had lower qualifying scores than recruits closer to mean handgrip strength. Simple Linear Regression generated a prediction equation for shooting accuracy based on handgrip strength, $F(1, 97) = 10.745$, $p=0.001$ with and R^2 of 0.10. The prediction equation was Qualifying Score = 232.175 + 0.805 (Grip Strength).

Only two left-hand dominant candidates participated in this study, therefore these individuals were eliminated from the data set and only right-hand dominant candidates were used. Thus, the data presented reflect only right-hand dominant participants. The means for handgrip strength for the recruits are shown in Table 1.

Table 1: Mean values for handgrip strength

	N	Mean	Std. Error
Entrylevel Grip Strength Right Hand	100	47.18	.801
Entrylevel Grip Strength Left Hand	100	44.63	.730
Prequalifying Grip Strength Right Hand	100	49.56	.730
Prequalifying Grip Strength Left Hand	100	46.51	.707
Post qualifying Grip Strength Right Hand	100	48.67	.754
Post qualifying Grip Strength Left Hand	100	46.76	.798
Valid N (listwise)	99		

Entrylevel = Grip strength trial upon entry and prior to firearms training.

Prequalifying = Grip strength trial the day prior to initial firearms training.

Post qualifying = Grip strength trial just after completion of qualification rounds.

The Mean handgun qualification scores are shown in Table 2.

Table 2: Mean Handgun Qualifying Scores

	N	Mean	Std. Deviation
Handgun Qualification Score	99	270.16	20.527

To determine whether or not any significant strength changes resulted from the Academy's training regime, paired t-tests were performed. The results for strength changes, from both dominant and non-dominant hands, are shown in Tables 3 and 4, respectively.

Table 3: Paired Samples Test for Grip Strength of the Right Hand

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval				
					Lower	Upper			
Pair 1	Entrylevel Handgrip - Prequalification Handgrip	-2.383	5.074	.507	-3.390	-1.376	-4.697	99	.000
Pair 2	Entrylevel Handgrip - Postqualfication Handgrip	-1.493	5.608	.561	-2.606	-.380	-2.663	99	.009
Pair 3	Prequalification Handgrip - Post qualification Handgrip	.890	5.013	.501	-.105	1.885	1.775	99	.079

Table 4: Paired Samples Test for Grip Strength of the Left Hand

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Entrylevel Handgrip - Prequalification Strength	-1.885	4.887	.489	-2.855	-.915	-3.857	99	.000
Pair 2	Entrylevel Handgrip - Post qualification Handgrip	-2.135	4.898	.490	-3.107	-1.163	-4.359	99	.000
Pair 3	Prequalification Handgrip - Post qualification Handgrip	-.250	4.589	.459	-1.161	.661	-.545	99	.587

To determine whether recruits' handgun qualifying scores could be determined by grip strength, a scatter gram depicting the association between handgrip strength and handgun qualifying score were constructed (Figures 1 and 2). Figure 1 shows the relationship between dominant handgrip strength and handgun qualifying score for the new recruits upon entry into the ISP academy. It is also interesting to note that in Figure 1, some recruits with high grip strength values had lower qualifying scores than recruits closer to mean handgrip strength.

Figure 1. The relationship between dominant handgrip strength and handgun qualifying score for the new recruits upon entry into the ISP academy. The prediction equation from regression analysis was Qualifying Score = 232.175 + 0.805 (Grip Strength).

Figure 2 shows the relationship between the dominant handgrip strength and handgun qualifying score for the recruits after 26 weeks of training, but prior to the handgun qualifying trial.

The prediction equation from regression analysis was Qualifying Score = 233.117 + 0.747 (Grip Strength).

Simple Linear Regression was performed and indicates significant regression equations at the 0.01 level. The regression using grip strength for the recruits upon entry into the academy was $F(1, 97) = 10.745$, $p=0.001$ with and R^2 of 0.10. The prediction equation was Qualifying Score = 232.175 + 0.805 (Grip Strength). The regression equation using grip strength for the recruits following 26 weeks of training, but immediately prior to

handgun qualifying was F(1, 97) = 7.430. p=0.008 with and R^2 of 0.071. The prediction equation was Qualifying Score = 233.117 + 0.747 (Grip Strength).

Discussion

It appears that handgrip strength increased from the initial measurement upon entry into the ISP academy compared to the dominant handgrip strength after 26 weeks of training ($P < 0.01$). However, following the handgun qualification round, after each recruit fired off 1,600 rounds, the dominant handgrip strength had a non-significant decrease ($P = 0.079$) when compared to either the entry-level strength or the pre-qualification grip strength. This decrease in grip strength is to be expected and can be attributed to fatigue due to the increased use of the forearm and hand structures needed to fire the handgun during the qualification round. However, the non-significant decrease may indicate that for the number of rounds shot, the strength deficits may not impact the accuracy of the shooter.

A similar pattern of strength and fatigue can be found for the non-dominant hand. A significant increase in strength occurred when comparing the entry-level handgrip strength to the prequalifying handgrip strength at the $P < 0.001$ level. In addition, following handgun qualification, no significant differences were found when compared to the prequalification handgrip strength ($P = 0.587$). In fact, the mean values of the pre and post qualifying strengths were very similar. The very small strength deficit observed may indicate that the non-shooting handgun support hand may not be the deciding factor in determining handgun qualifying score, thus accuracy for a law enforcement officer hitting their target when engaged in a live fire-fight.

Since the strength deficit of the non-dominant hand was negligible from pre-qualification to post-qualification, we decided to focus on the relationship and the predictability of handgun scores using the dominant hand. The scatter grams show a positive relationship between handgrip strength and handgun qualification score. In general, those with higher handgrip results scored higher on the qualifying round. This was consistent with both the entry-level handgrip strength and the pre-qualifying handgrip strength. In fact the regression variables are very similar using either entry-level or prequalifying handgrip score. With that in mind, we believe the entry-level score may represent a more realistic situation to apply the predictive regression equation, since a law enforcement officer may need to use a handgun in a non-trained state. Although the general trend indicated that qualifying scores increased with increased handgrip strength, it is interesting to note, from Figure 2, that some individuals with the highest handgrip strength demonstrated low qualifying scores. Because this involved only a few of the recruits, it is difficult to draw valid conclusions. However, from the limited data presented, it suggests that a strength threshold may exist, above which, handgun accuracy decreases. Furthermore, it would be interesting to investigate these high handgrip strength individuals more closely to determine whether this threshold phenomenon exists.

This study revealed a positive association between handgrip strength and handgun qualifying score and generated a prediction equation to predict handgun score based on handgrip strength. We believe this model needs further study in order to determine whether or not the generated equation is a valid predictor of handgun accuracy.

Conclusion

While handgrip strength is significantly associated with shooting accuracy, increased strength above a given point does not appear to lead to increased accuracy. Moreover, the small strength deficit observed in the non-shooting support hand suggests this hand may not be the deciding factor in determining handgun-qualifying scores. This study provides a prediction equation for shooting accuracy based on handgrip strength however it needs to be further developed and extended in order to validate its efficacy.

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***Acknowledgements**

This study was supported by the University of Evansville Alumni Research and Scholarly Activity Fellowship. The authors wish to express their thanks to the Indiana Law Enforcement Academy **and the Indiana State Police** for all of their assistance in this study.