

Hand size counts in safe handgun use

A surprising number of handguns are not safe for most female and some male users

Selection and use of handguns by police officers have serious safety ramifications, given the purpose and power of a handgun. If a police officer fires a handgun at someone, he or she must be able to draw, aim, and fire the weapon repeatedly, avoid injury from recoil, and hit what is aimed at. Although this group of events may not be "safe" for the person being aimed at, it constitutes safe operation from the officer's perspective. Any other outcome may injure innocent bystanders, expose the police officer to injury from recoil or from the subject, or allow the subject to escape.

I have served as a consultant in two lawsuits involving female plaintiffs, each of whom had applied for employment to police departments. Both claimed that a condition of employment was to qualify with a specific model of handgun and that the handgun in question was too large for safe operation. In each case it was found that the handgun was too large for the plaintiff to position her hand in the proper firing position (to be described next), and neither handgun could be fired safely.

In this article, I address the importance of the proper match between a handgun and its user's hand, describe a critical anthropometric dimension of the hand, and present a step-by-step method for selecting handguns.

Safe Hand Placement

In addition to other ergonomics considerations, the size of the police officer's hand is especially important in the proper use and selection of a handgun, because size, unlike strength, cannot be changed. To shoot safely, the hand must be positioned so the thumb crotch (the web between the thumb and index finger) is on the center of the backstrap (the rear of the handle) and the distal pad of the index finger (the pad beyond the last knuckle) is on the centerline of the trigger. The part of the distal pad in question is the part close to the distal index finger joint, but not so close that the distal index finger joint touches the trigger. With this placement the user is able to pull the trigger straight to the rear, and the recoil is channeled to the soft tissue of the thumb crotch.

If a female officer's hand is too small for the handgun, she has two choices, both of which are unsafe. If she places the backstrap properly in the thumb crotch, she cannot place the appropriate portion of her index finger on the centerline of the trigger. Pulling on the trigger causes a sidewise force to be exerted on the handgun (leftward for a right-handed person), which affects accuracy, even if she tries to compensate. The other bad choice is to rotate her hand around the handgun so the distal pad of the index finger is properly placed on the centerline of the trigger. In this position, the center of the backstrap rests against the thumb joint, which will be impacted by the recoil when the handgun is fired. In addition, the user will have to reposition the handgun for each shot, because the recoil will force the handgun back into the thumb crotch.

Literature Review

This topic has been addressed in prior publications, most notably by Atkins (1992), who looked at the importance of ergonomics in relation to five issues: weapons selection methods, upper body strength,

recoil energy, bore axis, and hand size. All these factors are important, but only one - hand size - cannot be altered by individual choice or effort. Atkins assessed the hand size issue by defining two measures: trigger reach, which is measured on the handgun, and grip length, which is measured on the user. She reported a significant difference between men and women in grip length and that handgun models vary significantly in trigger reach. However, as defined by Atkins, these measures do not match, so an individual cannot choose a specific handgun for proper ergonomic fit using these measures.

Radwin and Oh (1991; Oh & Radwin, 1993) researched handle and trigger size effects in handheld, trigger-operated power tools. Among their conclusions was the expected one: Smaller people preferred smaller handles. Similar to Atkins (1992), however, Radwin and Oh did not match tool measurements with anthropometric measurements.

My data sources are Humanscale 4/5/6 (Diffrient, Tilley, & Harman, 1981), Hand Anthropometry of U.S. Army Personnel (Greiner, 1991), and direct measurements of nine models of handguns (described in the next section).

Hand Data

Anthropometric measurements are made with the body in standard, reproducible positions. For the hand, this means that measurements are made with the hand extended and flat. However, when one places a handgun in the hand, with the center of the backstrap in the thumb crotch and the index finger wrapped around the trigger so that the pad of the outermost section (distal phalange) rests against the centerline of the trigger, both the first (distal) index finger joint and the second (medial) index finger joint must be bent. This bending decreases the effective length of the index finger and causes the adjacent flesh to fold and further decrease the effective length of the finger.

Because of these bends and folds, and the distance from the edge of the trigger to the centerline, an additional factor must be added to the distance between the thumb crotch and the first index finger joint. For my own hand, this additional factor is approximately .25 inch (6.4 mm). The resulting measure, which can be matched to corresponding handgun data, is designated trigger grip length. Although the .25-inch factor can be expected to vary with body size and gender, its variation should be small, and it should not affect trigger grip length appreciably. Trigger grip length as measured on a user is designated TGLU (illustrated in Figure 1).

Using data from Diffrient et al. (1981) and Greiner (1991), it is possible to correlate TGLU with the percentile of U.S. male and female adult populations. Diffrient et al. provided thumb crotch length (A) and index finger length (B); Greiner was used to obtain index finger distal phalange length (C). Trigger grip length in inches is thus the expression $A + B - C + .25$.

Figure 2 shows the variation of trigger grip length with percentile of U.S. adult men and women. The gray bar in Figure 2 corresponds to handgun measurements described in a subsequent section.

Handgun Data

The measurement designated trigger reach in Atkins (1992) is the appropriate handgun measurement to match with TGLU. In this article, the measurement on the hand is referred to as TGLU and the measurement on the handgun as TGLH. On a handgun, TGLH is the minimum wraparound distance from

the center of the backstrap to the centerline of the trigger, with the trigger fully forward. It can be determined for any handgun by wrapping a filament completely around the trigger and backstrap, measuring the resultant length of filament, and dividing this measurement by two.

TGLH was determined for nine handgun models by using the technique just described. After trying several materials and methods, I found that a filament consisting of an 18-gauge braided, insulated electrical wire gave good results. The wire was wrapped and overlapped around the backstrap and the trigger, then both strands were cut with a small wire cutter. The resultant length of wire was then straightened and measured with a steel rule. Each handgun was measured in the uncocked state.

Several handguns had a small amount of play in the trigger. Care was taken to make the measurement with the trigger as far forward as it would go, as the police officer would have to properly place his or her hand on the handgun in all circumstances. Table 1 lists the nine handgun models measured and their values of TGLH. Table 2 contains similar data from Atkins (1992) for 17 handguns. Note that the measurements for the Sig P220 in the two tables are less than .01 inch different.

An analysis of Figure 2 and Table 1 shows that several models of handgun are too large for a significant number of women and men to fire safely. The range of TGLH I measured is shown by the gray bar in Figure 2, with the S&W Model 410 at the bottom of the bar (3.60 inches, or 91.4 mm) and the Colt Model Z40 at the top (3.89 inches, or 98.8 mm). For the S&W Model 410, about 35% of women and 5% of men cannot position their hands properly to handle and fire the handgun safely. For the Colt Model Z40, approximately 59% of women and 24% of men cannot position their hands properly to handle and fire safely. Table 2 lists several handguns for which a proper grip can be achieved by all but a very small percentage of women.

Achieving Appropriate Ergonomic Fit

Because the meaning of trigger grip length is the same for the handgun and the user, a match can theoretically be made if one selects a handgun whose TGLH is equal to or smaller than the user's TGLU. The user should then be able to properly place his or her hand on the handle and the trigger. If the requirements of the other aspects of handgun selection have been met, such as upper body strength, recoil energy, and bore axis, the officer can use the handgun safely.

In practice, the handgun selection process is rather involved but still manageable. Simply follow these three steps:

1. Measure the TGLH of prospective handguns using the technique described earlier, or ask the manufacturers to produce the data.
2. Determine the TGLU for a prospective user. This step is more difficult, because even experienced practitioners find anthropometric measurements difficult to make accurately. A commonsense approach is to establish the percentile position of the user relative to the adult U.S. male or female population in a simpler way, then use Figure 2 to determine the user's TGLU. One easily measured variable is index finger length (distance from the middle of the crease at the base of the index finger to the tip). Table 3 contains index finger length data from Greiner (1991).
3. Select one or more handguns for which TGLH is equal to or smaller than the user's TGLU, and conduct meaningful handling and shooting trials to verify that they fit the user's hand. Some of

the larger ones may be slightly too large because of data inconsistencies, measurement error, or the user's personal characteristics. If the user can place the backstrap of the handgun in the thumb crotch and place the distal phalange pad across the centerline of the trigger, the fit is acceptable for safe handgun operation.

The guidelines included here can be applied by police departments in need of information to equip female officers with handguns that can be used safely. In addition, they can be relevant for anyone operating a trigger-operated tool.

References

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