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EFFECTS OF BODY ARMOR FIT ON MARKSMANSHIP PERFORMANCE

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14. ABSTRACT
This study examines the effect of body armor fit on marksmanship performance. Specifically, (1) does wearing body armor affect marksmanship performance, and (2) does the fit of the armor affect marksmanship performance. Fifteen male Soldiers participated in a marksmanship performance task using a weapon simulator in four different body armor configurations (no armor, initial fit, increased and decreased size). Accuracy (closeness to target center), precision (shot group tightness), and speed (transition time) were measured. Accuracy and precision were not significantly different regardless of body armor fit. However, speed was degraded in the initial fit body armor size and the increased size configurations relative to the baseline and decreased size configurations. In other words, in the decreased size, Soldiers engaged targets as quickly as when not wearing body armor, indicating body armor fit may impede a Soldier's ability to transition between targets, thereby impacting mission performance.

15. SUBJECT TERMS

FIT	BODY ARMOR	PROTECTIVE CLOTHING	PERFORMANCE(HUMAN)
TARGETS	MARKSMANSHIP	HUMAN FACTORS ENGINEERING	PROTECTIVE EQUIPMENT
WEAPONS	ANTHROPOMETRY	PPE(PERSONAL PROTECTIVE EQUIPMENT)	
SIMULATORS	SIZES(DIMENSIONS)	IOTV(IMPROVED OUTER TACTICAL VEST)	

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Effects of Body Armor Fit on Marksmanship Performance

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Abstract This study examines the effect of body armor fit on marksmanship performance. Specifically, (1) does wearing body armor affect marksmanship performance, and (2) does the fit of the armor affect marksmanship performance. Fifteen male Soldiers participated in a marksmanship performance task using a weapon simulator in four different body armor configurations (no armor, initial fit, increased and decreased size). Accuracy (closeness to target center), precision (shot group tightness), and speed (transition time) were measured. Accuracy and precision were not significantly different regardless of body armor fit. However, speed was degraded in the initial fit body armor size and the increased size configurations relative to the baseline and decreased size configurations. In other words, in the decreased size, Soldiers engaged targets as quickly as when not wearing body armor, indicating body armor fit may impede Soldier's ability to transition between targets, thereby impacting mission performance.

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Keywords Body armor · Fit · Anthropometry · Marksmanship performance · Weapon simulator · Personal protective equipment (PPE) · Human factors · Military

1 Introduction

For all U.S. military personnel, body armor is essential personal protective equipment (PPE). The primary purpose of body armor is to "provide the Soldier with enhanced protection from small arms threats and fragmentation and munitions during ballistic and blast events, while maintaining comfort and maneuverability" [1]. Since body armor is not custom made, but a sized item with a limited number of sizes, it is not always possible to issue an optimal fitting system that guarantees maximal comfort and maneuverability to all Soldiers. Accordingly, potential performance degradation, due to body armor, is frequently anticipated and observed [2]. Thus, it is easy to assume that if an optimal body armor size is worn, any concerns regarding performance, comfort and maneuverability can be minimized.

To date, there has been no quantitative investigation of the effects of body armor fit quality on mission performance that can be used for body armor design. A systematic understanding of the relationship between mission performance and body armor fit may allow armor designers to create an improved product that allows users to complete their mission more efficiently and safely. The current study is a part of larger project that investigates the relationship among anthropometric variability, body armor fit, area of coverage (AoC), mobility, and performance, with a goal of improving body armor design. This study examines the effect of body armor fit on marksmanship as one aspect of mission performance.

Marksmanship, the skill of using a firearm, is an important basic combat and counterinsurgency (COIN)-related skill in the U.S. Army [3]. For this study, a rifle marksmanship task was selected as a component of mission performance to investigate the effect of body armor fit. Marksmanship performance was measured in two ways, skill level (how accurately and precisely a shooter can perform the marksmanship task), and transition mobility (how fast a shooter can transition from one target to another, horizontally, vertically and diagonally). Accuracy (closeness to target) and precision (shot group tightness) were used to evaluate the level of shooting skill. Speed (transition time) quantified the transition mobility while wearing body armor. The research questions of this study were: (1) how does wearing body armor affect marksmanship performance, and (2) does the fit of the body armor affect marksmanship performance?

2 Methods

2.1 Subjects

Fifteen male, active duty Soldiers volunteered for this study and completed all test conditions. Test participants' (TPs) ranged in age from 18 to 28 years (M = 21.13, SD = 3.48). The average body weight, height and body mass index (BMI) of the TPs were 82.0 kg (SD = 10.6 kg), 1734.2 mm (SD = 65.4 mm) and 27.3 (SD = 3.1), respectively. Relative to the current U.S. Army population [4], TPs' size distribution is represented in Fig. 1.

2.2 Test Configurations

All test configurations were counterbalanced to control for order effect.

Body Armor. The U.S. Army, standard issue Improved Outer Tactical Vest (IOTV) Generation III body armor system was used for the current study (Fig. 2). Four different configurations were tested: no body armor, duty uniform only (baseline); initial fit body armor size (initial size); one size smaller than initial fit size (decreased size); and one size larger than initial fit size (increased size). In all configurations, TPs also wore an Advanced Combat Helmet.

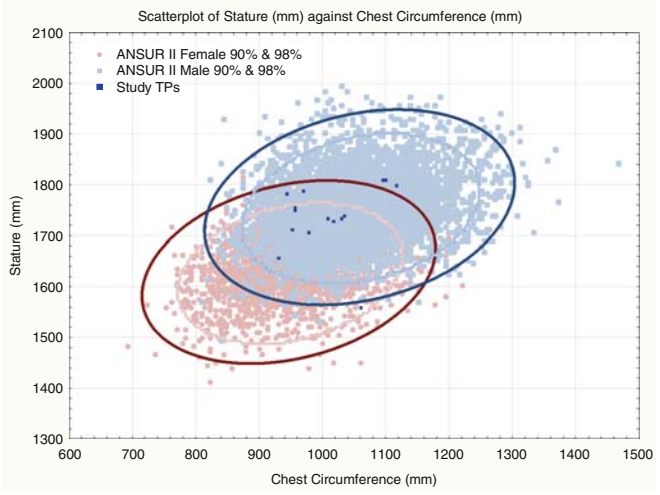

Fig. 1 Distribution of stature by chest circumference for 15 TPs (*dark blue dots*) relative to ANSUR II 2012 (*light blue* and *red dots*) [4]

Fig. 2 Improved outer tactical vest (IOTV) Gen III

Table 1 Distribution of predicted fit versus initial fit IOTV size

	Initial fit size						
	Chest Circ. (in.)	XS	SM	MED	LRG	XL	Total
Predicted by legacy size (chest circumference)	XS (29-33)	–					–
	SM (33-37)		1				1
	MED (37-41)		4	6			10
	LRG (41-45)				4		4
	XL (45-49)					–	–
	Total		5	6	4		15

Initial fit body armor size is the body armor size for an individual, as determined by a fit expert, via visual inspection, to be the best fitting size of available IOTV sizes. The fit expert started with the predicted size (see the sizing chart in Table 1) based on the TP's chest circumference, assessed that fit, and tried smaller and larger sizes, as needed. Then, the fit expert determined the initial fit size that provided required coverage/protection on the chest with the best apparent mobility of all tested sizes.

Ten of the 15 TPs predicted into size Medium; however, four of those TPs were assigned the size Small as their initial fit by the fit expert (Table 1). One TP predicted into a size Small and the other four predicted into size Large; all of these TPs were assigned their predicted sizes as initial fit size. No individuals predicted into size Extra Small or Extra Large.

Shooting Postures. A total of three different shooting postures were employed. These included: standing unsupported (Standing), kneeling unsupported (Kneeling), and prone unsupported (Prone). Appropriate shooting postures were employed based upon the task scenario (refer to Sect. 2.4). Prone posture was not evaluated in the multiple target task because transitioning between targets at that great of an arc (≥50°) was not operationally realistic.

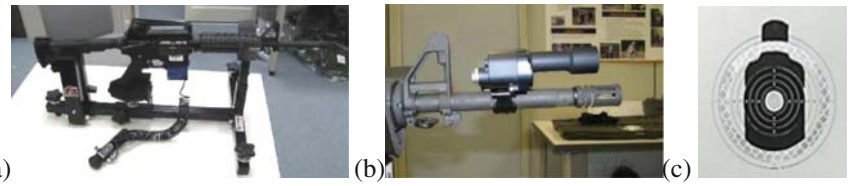

Fig. 3 Image on the *far left* **a** shows the de-militarized M4 weapon with integrated CO_2 recoil simulator. Image in *center* **b** shows the FN MilTrainer optical unit mounted to the barrel of the weapon. Image on the *far right* **c** shows the paper targets [5]

2.3 Marksmanship Weapon Simulator

A Fabrique Nationale (FN) (formerly Noptel) MilTrainer weapon simulator system was used to collect marksmanship performance data. The FN MilTrainer optical unit was mounted on the barrel of a de-militarized M4 carbine with an integrated carbon dioxide (CO_2) recoil simulation system (the mock weapon and CO_2 system were manufactured by LaserShot, Inc.).

As shown in Fig. 3, the targets were paper ring targets scaled to represent a full-size E-Type Silhouette target at 75 m when placed 5 m away from the shooter. TPs used the standard "iron sights" common to M4/M16 style rifles. The sights were kept adjusted to Battle-sight Zero, and the MilTrainer optical unit was adjusted to ensure the hit position recorded by the simulator was aligned with the settings of the weapon sights [5].

2.4 Test Scenario

TPs performed two marksmanship tasks, a single target task and a multiple target task. The target setup was identical for both tasks (Fig. 4). TPs used all five targets

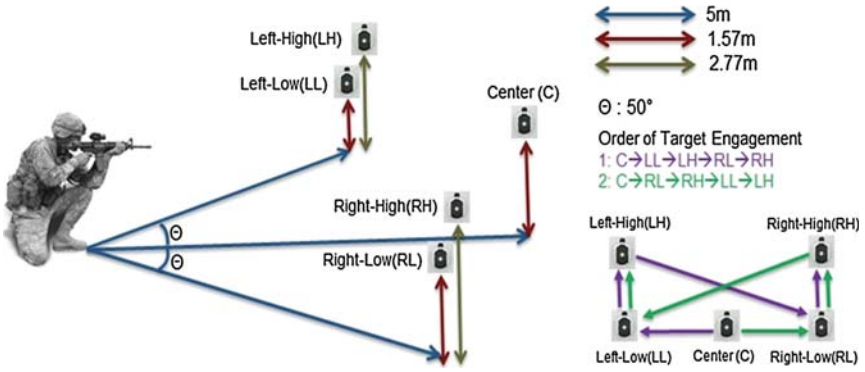

Fig. 4 Marksmanship test layout

in the multiple target task, but used only the center target in the single target task (Fig. 4).

Practice Session. Prior to data collection, TPs had a practice session followed by a qualification test. TPs qualified if 70 % of 10-standing position shots, 80 % of 10-kneeling position shots and 90 % of 10-prone position shots were within the "6" ring of the target. Once qualified, TPs initiated the experiment. The entire test scenario in each body armor configuration was completed during one 3–4 h test session.

Single Target Task. In the single target task, TPs aimed at the center target, positioned 5 m away from the center of the body, and took 25 shots (five groups of five shots) in each test configuration. The single target task evaluated the success of each shot group for accuracy and precision. A shot group is defined as a series of shots fired at the same point of aim (POA) from the same position and weapon barrel. In each test configuration, there was no time limit on obtaining an optimized body position, prior to firing. Once TPs started, the simulator system captured the information.

Multiple Target Task. There were five different stationary targets positioned at five different locations, including the center target also used in the single target task. TPs fired one shot per target, following the order of target engagement. They repeated firing in sequence until five series of five shots were completed. The order of target engagement was either: "center → left low → left high → right low → right high" and then "center → right low → right high → left low → left high" or vice versa (Fig. 4). For all test configurations, TPs fired a total of 50 shots, 25 shots following each order of target engagement.

The main purpose of the multiple target task was to evaluate the transition mobility or how quickly TPs moved from one target to the next. TPs were allowed as much time for their first shot as needed and therefore, shot accuracy for the center target was not compared to that of other targets. TPs were instructed to move from one target to the next as quickly as possible without sacrificing accuracy. Since each series of five shots were fired from five different POA to five different targets, those five shots were not considered as a shot group. Thus, precision was not an applicable measure to evaluate, however accuracy was measured to ensure there was consistency in a TPs' efforts.

2.5 Measures of Marksmanship Performance

Precision. Precision refers to the closeness of shots to each other within a shot group, regardless of closeness to the center of the target. The popular term for marksmanship precision is often "shot group tightness." The smaller the dispersion within the shot group, the better the precision. The primary measure of marksmanship precision, "variable error," was computed and indexed by the "mean radius (MR)" [6, 7].

Accuracy. Accuracy refers to how close to the target center a shot in the shot group is. It measures a TP's ability to hit the target center accurately. As computed in this study, accuracy refers to shooting errors based on the average of the distances from the center of mass (DCM) [6]. Theoretically, if a shot hits exactly at the target center, the distance between the target center and the shot is 0 and the accuracy is perfect.

Speed. Speed refers to the movement time between targets. In the multiple target task, TPs were required to transition their aim between each target (e.g., from center target to left low target) prior to firing; the time it took the TP to execute those two shots was the movement time. Transitions could be in three directions: horizontal, vertical or diagonal. Movement time was derived from the time stamp produced in the FN MilTrainer software.

2.6 Data Editing

All 15 TPs performed a total of 28 marksmanship trials across the different body armor configurations and shooting postures: 12 trials for the single target task and 16 trials for the multiple target task. The FN MilTrainer software produced 28 XML files, one file per trial. Manually editing data from each file (approximately 2700 lines of data) was a time—and labor-intensive process, prone to user error and suboptimal data throughput.

A custom data editing process tool developed in-house (NOPTEL_PARSE, Version 1.2) was used to assist in the post processing of the data to prepare it for analysis. NOPTEL_PARSE provided a robust, command-line interface for automatically parsing NOPTEL XML data and calculating TP measurements (MR, DCM, and movement time). Data and errors from these files were exported as comma delimited spreadsheets which were imported into a database and statistical software for analysis.

2.7 Data Analysis

For all measures of marksmanship performance, repeated measures ANOVAs were performed to investigate the statistical significance. For the single target task, body armor configuration and shooting posture were the two factors used to measure precision and accuracy. For the multiple target task, there were two additional factors, target location and order of engagement. Target location identified each target (left low, left high, right low and right high targets) to investigate the accuracy as the third factor along with body armor configuration and shooting posture. Similarly, order of target engagement was the third factor for speed with the other two factors, body armor configuration and shooting posture. Order of target engagement is the path the TP followed to engage each target: horizontal

(center to left low, center to right low), vertical (left low to left high, right low to right high), and diagonal (left high to right low, right high to left low) directions. For the three-way repeated measures ANOVAs, the model was reduced with all three main effects with two-way interaction terms associated with the body armor fit configuration.

For all repeated measures ANOVA tests, the concept of sphericity was examined by Mauchly's test [8]. If the concept of sphericity was violated, one of the alternative statistics was used, either the Greenhouse-Geisser correction, when the epsilon was smaller than 0.75, or the Huynh-Feldt correction, when the epsilon was greater than 0.75 [9]. When there were significant main effects or interaction effects, Bonferroni tests with adjustments were used to analyze pairwise comparisons ($\alpha < 0.05$). IBM's Statistical Package for the Social Sciences (SPSS 21), Statistica V12 and Microsoft Excel 2013 were used to perform data analyses and to create tables and graphs.

3 Results

3.1 Body Armors' Effect on Marksmanship Performance

To determine the effect of body armor on marksmanship performance, the baseline and initial size configurations were compared for precision, accuracy, and speed.

Precision. Precision was assessed only for the single target task, since the shots fired to each target in the multiple target task were not from the same POA. A two way repeated measures ANOVA was performed to investigate the main effects of configuration and shooting posture and their interaction effect. The smaller the MR, the tighter the shot group, and the better the precision. No statistically significant difference was detected between the baseline (M = 80.3 mm, SD = 20 mm) and the initial size (M = 80.0 mm, SD = 15 mm) configurations for precision, $F(1, 14) = 0.01$, $p = 0.69$. Precision was significantly different by shooting posture, however, $F(2, 28) = 18.07$, $p = 0.00$, Bonferroni adjustments revealed that TPs were the most precise in the prone posture (M = 63 mm, SD = 18 mm), followed by kneeling (M = 81 mm, SD = 19 mm), with standing resulting in the worst precision (M = 97 mm, SD = 26 mm), $p < 0.05$. The interaction effect of configuration and posture was not significant, $F(2, 28) = 0.57$, $p = 0.57$. For both baseline and initial size configurations, prone posture resulted in the most precision, followed by keeling, while the standing posture had the least precision.

Accuracy. Accuracy was assessed in both the single target and the multiple target tasks. For the one target task, a two way repeated measures ANOVA was performed to investigate the effects of configuration and posture, and a one way interaction with configuration. There were no significant effects for accuracy (configuration, $F(1, 14) = 0.07$, $p = 0.80$; posture, $F(2, 28) = 1.08$, $p = 0.35$; or interaction, $F(2, 36) = 1.63$, $p = 0.21$).

For the multiple target task, a three way repeated measures ANOVA was performed to investigate the main effects of configuration, shooting posture, and target location, along with the two way interaction effects with configuration. All targets except for the center target were compared to one another for accuracy. Accuracy between the baseline (M = 231 mm, SD = 68 mm) and initial size (M = 228 mm, SD = 70 mm) configurations was not statistically different, $F(1, 14) = 0.067$ $p = 0.80$. However, shooting posture had an effect on accuracy, $F(1, 14) = 12.74$, $p = 0.00$; accuracy was better when standing (M = 219 mm, SD = 66 mm) than when kneeling (M = 240 mm, SD = 65 mm). There was no statistical difference for accuracy based on target location, which confirmed that there was consistency in a TPs' efforts, $F(3, 42) = 1.14$, $p = 0.34$. Furthermore, there was no interaction effect between configuration and posture or target location, $F(1, 14) = 0.24$, $p = 0.63$ and $F(3, 42) = 0.66$, $p = 0.58$, respectively.

Speed. Movement time, the time to transition between targets, was assessed in the multiple target task. A three way repeated measures ANOVA was performed to investigate the main effects of configuration, shooting posture, and the direction (order of target engagement), in addition to the two interaction effects with configuration.

The movement times for the baseline and initial configurations were statistically different, $F(1, 14) = 5.05$, $p = 0.04$. TPs moved faster from one target to the next when they wore the baseline (M = 1.69 s, SD = 0.53 s) than in the initial size configuration (M = 1.90 s, SD = 0.78 s), $p < 0.05$. The movement time was also statistically different depending on the shooting posture, $F(1, 14) = 7.79$, $p = 0.01$. TPs' movement time was shorter when they performed in the standing posture (M = 1.57 s, SD = 0.39 s) than in the kneeling posture (M = 2.01 s, SD = 0.93 s).

Movement time also differed depending on the engagement direction, $\mathcal{E} = 0.32$, $F(1.59, 22.25) = 23.3$, $p = 0.00$. Within the two symmetrical orders of engagement, there were six different routes to transit from one target to the next (e.g., center target to left low target). Those six routes consisted of three different types of directions for both left and right transitions. These included horizontal (center to left low target and center to right low target), vertical (left low to left high target and right low to right high target), and diagonal transitions (left high to right low target and right high to left low target). On average, the movement time was shortest for vertical movements, followed by horizontal movements, with diagonal movements taking the longest, $p < 0.05$. This seems obvious because the distance traveled for the vertical movement (1.2 m) was the shortest, followed by horizontal movement (5.24 m) and the diagonal movement (7.7 m) was the longest.

Within the same direction (i.e., vertical, horizontal or diagonal), two symmetrical movements (e.g., left to right or right to left) were not different from each other, $p > 0.05$. It took a similar amount of time to move vertically from the left low target to the left high target (M = 1.32 s, SD = 0.36 s), and from the right low target to the right high target (M = 1.25 s, SD = 0.36 s), $p > 0.05$. A similar trend was found for the horizontal and diagonal movements, $p > 0.05$ (center target to left low target, M = 1.85 s, SD = 0.71 s; center target to right low target, M = 1.84 s,

SD = 0.80 s; and left high target to right low target, *M* = 2.26 s, *SD* = 0.99 s; right high target to right low target, *M* = 2.25 s, *SD* = 0.84 s, respectively).

There was no significant interaction for configuration by posture, $F(1, 14) = 1.11$, $p = 0.31$. Within the same shooting posture, TPs moved faster in the baseline configuration than in the initial size configuration. The interaction between configuration and order of target engagement was approaching significance, $\mathcal{E} = 0.57$, $F(2.85, 39.85) = 2.29$, $p = 0.09$. There was no difference in movement time between baseline and initial size configurations for the vertical movements, $p > 0.05$. However, TPs moved significantly faster in the baseline compared to their initial size for the horizontal movements, by 0.24 s and for the diagonal movements, by 0.29 s, $p < 0.05$. Given the distance for each movement, it is highly likely that as the travel distance gets longer, so does the delay in movement time for the initial size relative to the baseline configuration.

3.2 Impact of Body Armor Fit on Marksmanship Performance

Given that there does appear to be an impact on marksmanship performance due to the addition of body armor, primarily for the objective measure of speed, the impact of body armor fit on marksmanship performance (precision, accuracy, and speed) was also investigated. The delta values between performance in each body armor configuration and performance in the baseline configuration were calculated and used to analyze the impact of fit on performance. Those deltas were converted to percent differences to represent the improved (greater than 100 %) and degraded (less than 100 %) performance relative to the baseline. The baseline (duty uniform) represents a TP's performance without any effect from the body armor.

Precision. There was no statistical differences in delta values due to either body armor fit configuration, $F(2, 28) = 0.08$, $p = 0.93$, or shooting postures, $F(2, 28) = 0.44$, $p = 0.65$, nor was there any interaction effect between the body armor fit configuration and posture, $F(4, 56) = 0.95$, $p = 0.44$.

Accuracy. For the single target task, there was no significant difference in delta values due to either body armor fit configuration, $F(2, 28) = 0.65$, $p = 0.53$, or shooting posture, $F(2, 28) = 0.39$, $p = 0.68$, nor was there any interaction effect between the body armor fit configuration and posture, $F(4, 56) = 0.23$, $p = 0.92$.

The results were the same for the multiple target task. There was no significant difference in delta values due to body armor fit configuration, $F(2, 28) = 0.53$, $p = 0.60$, shooting posture, $F(1, 14) = 0.09$, $p = 0.77$, or target location, $F(3, 42) = 0.81$, $p = 0.50$. There was also no significant interaction effect between shooting posture and body armor fit configuration, $F(2, 28) = 0.47$, $p = 0.63$ or between target location and body armor fit configuration, $F(6, 84) = 0.71$, $p = 0.64$.

Speed. For the multiple target task, there was no significant difference due to shooting posture, $F(1, 14) = 0.00$, $p = 0.98$, or direction, $\mathcal{E} = 0.65$, $F(3.25,$

45.51) = 1.75, $p = 0.13$, nor were there any interactions between body armor fit configuration and shooting posture or direction, $F(2, 28) = 2.03$, $p = 0.15$ and $\mathcal{E} = 0.24$, $F(2.42, 33.81) = 1.55$, $p = 0.13$, respectively. However, the delta values of movement time were statistically different depending on the fit of the body armor, $\mathcal{E} = 0.83$, $F(1.67, 23.31) = 4.91$, $p = 0.02$. Regardless of the engagement direction, TPs moved faster from one target to the next when they performed in their decreased size configuration ($M = -0.02$ s or 101.05 % of baseline configuration) compared to speeds in their initial fit and increased size configurations, $p < 0.05$. The difference in movement time between initial fit size (M = 0.20 s, or 87.90 % of baseline configuration) and increased size (M = 0.20 s or 88.01 % of baseline configuration) was almost identical, $p > 0.05$.

4 Discussion

This study started with two research questions, (1) how does wearing body armor affect marksmanship performance, and specifically, (2) does the fit of the body armor affect marksmanship performance? In order to investigate both questions, marksmanship performance using a weapon simulator was evaluated in terms of skill level and transition mobility. Accuracy and precision evaluated the level of shooting skill; speed (movement time to transition between targets) quantified the transition mobility in various body armor configurations.

4.1 Skill Level

Shooting posture was the only factor that had a statistically significant effect on precision, and no other factors, either body armor fit configuration or the interaction between shooting posture and configuration were statistically significant for precision.

During the single target task, no statistically significant differences in accuracy were observed for configuration, shooting posture, or interaction effect. During the multiple target task, no statistically significant differences were found due to configuration, target location or the interaction between them. However, unlike in the single target task, when TPs were required to move the weapon and transition between targets, their accuracy was more degraded while kneeling than while standing.

In all, body armor fit neither further degraded nor improved marksmanship performance (precision and accuracy) relative to the baseline configuration without body armor.

4.2 Transition Mobility

For speed, all main effects were statistically significant and the interaction effect between configuration and the direction (order of target engagement) was also approaching significance when comparing baseline and initial fit configurations. TPs moved faster when they performed in a standing posture relative to kneeling, and in baseline relative to initial size. Interestingly, the further the distance between each target was, the more apparent the performance difference between baseline and initial size configurations became. Thus, the effect of body armor relative to the baseline configuration, was that it caused TPs to be slower in their transitions between targets, and the greater the transition distance required, the slower they performed.

Interestingly, body armor's effect on speed was different depending on the fit of the body armor. When all configurations are compared to each other, the transition time between two targets for baseline, decreased, initial fit, and increased size configurations are 1.69, 1.67, 1.90 and 1.89 s, respectively (Fig. 5a). If the total movement time for all five target engagements are compared, the mean speed was

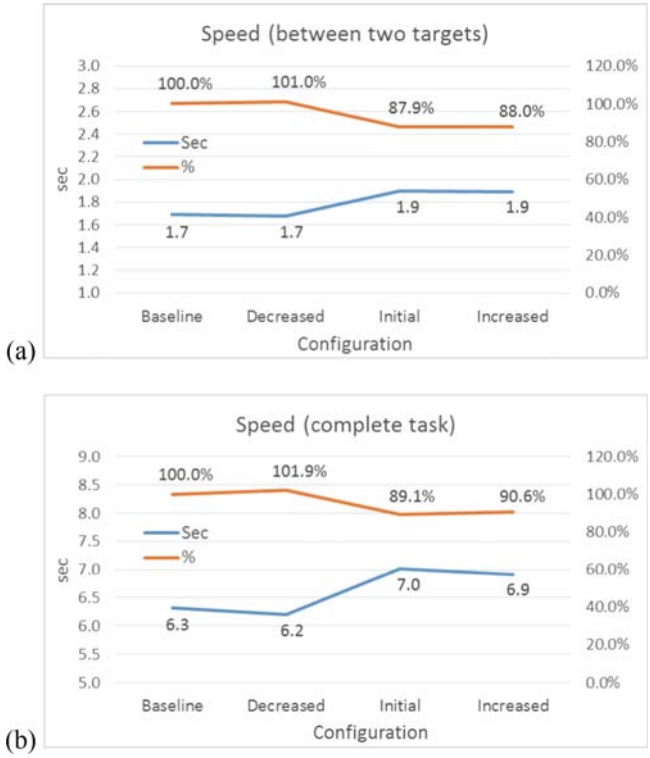

Fig. 5 Results of transition speed between **a** two targets and **b** all targets speed

maintained in the decreased size (M = 6.2 s, 101.95 %) relative to baseline (M = 6.32 s), but was degraded in the initial and increased sizes by 0.69 s (10.93 %) and by 0.60 s (9.42 %), respectively (Fig. 5b). Therefore, TPs' speed was statistically faster in the decreased size than it was in the initial or increased size. Remarkably, the speed in the decreased size was almost identical to that in the baseline, meaning that Soldiers' performance in the decreased size body armor was similar to their performance when not wearing any body armor.

4.3 Performance Coverage Trade off in Body Armor Design

Although the current results are from a limited number of Soldiers utilizing a controlled, laboratory based scenario, these results indicate two facts. One, regardless of fit, wearing body armor did not degrade or improve the skill level of marksmanship performance relative to the baseline configuration in this experimental setting with a simulator. Two, depending on the fit of the body armor, transition mobility during marksmanship performance can be maintained or degraded relative to the baseline configuration.

Thus, from a performance perspective, it is debatable whether body armor design specifications should aim to fit the Soldier in a size decreased from the size that currently would be predicted and issued. However, because the primary concern in body armor design is to protect the body from blast/ballistic threat(s), it is critical to further investigate the risk inherent (e.g., increased potential for injury) in selecting smaller sizes over initial fit sizes in order to improve performance. Currently, there are only two known factors that characterize the differences between two consecutive sizes of body armor: weight and area of coverage (AoC). When body armor is configured with soft armor, collar, yoke, and plates (front, back with two side plates), Soldiers would wear approximately 1 kg less by wearing an IOTV one size smaller on average (across the sizes from size Extra-Small to Extra-Large). For example, a size Small IOTV weighs 10.47 kg in comparison to a size Medium's 11.49 kg. Similarly, AoC is also reduced by wearing a smaller size, by 3.9 % between size Small and Medium as measured for those TPs in this study with an initial fit of Medium.

It is questionable whether the performance degradation/improvement is due to the difference in weight, AoC, or both. While we know that a reduction of weight is beneficial, the more critical question that should be addressed is the consequences of reduced coverage on Warfighter protection, and whether the performance improvement is worth sacrificing that additional protection. Currently, investigations on changes in protection relative to coverage reduction are being planned. These results will feed into recommendations on future body armor design.

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