Mind-Body Integrative Training: Firefighter Personal Protective Equipment (PPE)

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Abstract
The purpose of this research is to determine if differences in performance outcomes exist between the use of paramilitary instruction and a method of teaching informed by the Chinese philosophy Tài Chí when learning to don structural fire-fighting clothing or personal protective equipment (PPE). We hypothesize that keeping students in a process focus (i.e., Tài Chí method) rather than a high-pressure outcome focus (traditional paramilitary method) results in increased proficiency in the skill-performance outcomes (Selk, 2009). The assumption is that Tài Chí helps integrates students’ minds and bodies in the learning process and results in a higher quality of motor learning. The hypothesis is tested using an experimental design with test and control groups of students from Utah Valley University (UVU). Both the speed and degree of mastery of the skill are tested based on state standards for firefighters. Findings provide evidence that the steady motor-training method (Tài Chí) is a better approach than the traditional paramilitary technique of teaching the skill of donning structural fire-fighting equipment.

Introduction
In modern society, a system of emergency response has been developed to protect citizens of our communities against the threat of fire. This system is comprised of dedicated, hard-working, and well-trained firefighters. For the majority of fire-fighting personnel, needed training is delivered by a fire academy. The National Fire Protection Association® (NFPA®) has established clear certification safety standards for these academies. Furthermore, state fire officials have mandated specific certification standards based on job-performance requirements that each person must meet to achieve the title firefighter. Because of these standards, a majority of fire programs adopt a paramilitary environment for such training. The term paramilitary refers to the organization of the program resembling that of military basic training, wherein the teaching style emphasizes high-stress environments focusing on accomplishing tasks in a given time period. This instructional environment is designed to help recruits achieve the standards set forth by the governing bodies. One particular aspect of learning focuses on turnout drills. These drills are designed to teach the recruits how to don their personal protective equipment (PPE) in an emergency.

Utah Valley University’s (UVU’s) Recruit Candidate Academy (RCA) has adopted this paramilitary teaching context and its methods. Recruits are introduced to the proper way of donning their PPE. Recruits repeatedly practice the process. After some practice, the instructors begin to implement punishment for failure to complete the skills correctly. A time limit is established; and if not met, a physical activity is implemented as a fixed punishment. This punishment is usually in the form of push-ups, calisthenics, or running. Candidates are drilled, tested, and so punished until they complete the skill within the allotted period of time. Any step that is skipped in the performance of the skill is regarded as incomplete and results in a failure of the test.

The method in which the UVU’s RCA uses paramilitary tactics and high-stress environments may, in fact, not be the most effective way of educating new recruits. Theory and research from sports and performance psychology suggest that the use of high-stress training combined with interrupted motor training is less effective than steady motor training provided in less stressful environments. Research reported here examines potential benefits gained by the use of steady motor practice instead of having recruits try to dress quickly under the pressure of being punished.

Literature Review
The majority of current practices used in preparing athletes (or in our case firefighters) for competition revolve primarily around practice of the technical aspects of movement with far less emphasis placed upon systematic training (Abernethy, 1999). Applied to firefighters, the step-by-step process of donning PPE is emphasized and affirmed by instructors closely inspecting student performance for missed steps like enclosures not being closed or skin being exposed where the garments are meant to overlap. Abernethy (1999) contends that not all types of practice are likely to be equally effective in promoting the development of expert performance. That being said, there are two options of training that can be used: (1) demonstrating an example of putting on PPE and allowing firefighter recruits to develop their own processes of donning the gear but emphasizing haste and completely donned ensembles or (2) demonstrating the steps of donning
the PPE and encouraging students to use a steady rhythmic approach to practicing and allowing speed in dressing to come naturally. Traditionally, as noted previously, UVU’s RCA employed the first instructional method. In this study, firefighters learning to don their PPE using this method were called the control group. In contrast, firefighters using the second method (steady rhythmic approach) to don their turnout gear became the test group. We assumed that when tested, the recruits who use the steady rhythmic approach to practice getting into their PPE would have a higher rate of proficiency than the control group. Proficiency is defined as the degree to which students completed the required step in less than or a time equal to the maximum amount of time set by the fire-academy standard.

MacPherson, Collins, and Obhi (2009) explain that nonrhythmic movement characterizes inefficient or suboptimum movement performance. In contrast, rhythmic movement can improve gross motor skills performance; one ought to regard rhythm as a critical component of preparing for psychophysical performance (MacPherson, Collins, & Obhi, 2009). It was this overall rhythmic steady motor training that we believed would an ideal method of learning new skills required in the donning of PPE.

The second aspect of the current UVU’s RCA training method is inducing a high-pressure environment, particularly by punishing students for inadequate performance. This method, however, tends to decrease the proficiency of performance of unmastered skills during their acquisition. Yerkes and Dodson (1908) found that the relationship between arousal and performance proficiency approximates an inverted U, such that the optimum level of arousal is inversely related to task difficulty. Jackson and Csikszentmihalyi (1999) have called optimal performance the flow, which is a balance between the person’s current ability and the challenge of the task being performed. The more the challenge exceeds the person’s skill competence, the greater the experienced arousal and lower the efficacy in the performance. Christianson (1992) explains that excessive emotional arousal beyond what is individually optimal is correlated with successively lower degrees of learning and memory. In the case of the UVU’s RCA, the high-stressed training method used can very easily push recruits over the optimal level of pressure and anxiety. In fact, the time pressure and threat of punishment tended to increase the perceived size of the challenge for many students. On the other hand, we believed that the steady rhythmic approach to practice would more likely maintain the balance between the challenge of the skill and motor-skill level as it developed and thus approximating each candidate’s relative optimum arousal.

In addition, Christianson (1992), quoting Mandl (1975), explains about the physiological effects of the high-stress training method:

In situations in which the arousal of the sympathetic nervous system or emotional arousal becomes very intense, “it floods the attention mechanisms and decreases the amount of information that the organism can recruit effectively either from the environment or from its own memory store.” (p. 298)

As such, due to the proven negative effects of anxiety, especially in the training of novice entry-level learners, a steady rhythmic approach may prove more beneficial. The UVU’s RCA instructional program should consist of strategies aimed at encouraging a positive appraisal of the challenge and personal capabilities of the learner (Hill, Hanton, Fleming, & Matthews, 2009). By decreasing the amounts of stress and anxiety involved, the use of effective steady rhythmic training could result in higher levels of skill proficiency.

Experiencing the flow, or optimal performance, is more than just focus; it is a harmonious experience of mind-body integration that feels effortless and as if something special is happening (Jackson & Csikszentmihaly, 1999). For example, Maslow (1994) explains that people who have such peak experiences feel a unity or convergence of all things in the moment. In other words, there is a perceived seamlessness between an individual’s sense of self and his or her environment.

Mind-body integrative training is inspired by the ancient martial arts philosophy and method for teaching Kung Fu known as Tài Chí Chuán. While the philosophy of Tài Chí has many metaphysical principles involved in its theories and practice (Lo, Inn, Amacker, & Foe, 1979), its primary importance to this study is its focus on mind-body integration. Strength and speed come through the economy of motion of its flowing style. Tài Chí Chuán says,

If there is any uncoordinated place, the body becomes distorted and weak. First the mind is used to order the body. Later your body can follow your mind, and you can control yourself and still follow your opponent. (Lo et al., 1979, p. 74)

The principle of learning each step of a skill one by one and not getting the body ahead of the mind’s ability to organize the movements is important. The idea is to allow the speed of the trainee to increase naturally as the steps in donning PPE gear are learned through practice without tension. Carlstadt (2004) points out that when a person is under pressure in a critical moment in sports, the increased anxiety can manifest itself physically in the increased flexing of the primary muscles that the athlete needs to move as intended, but opposing irrelevant muscle structures also increase in flex, which results in increased rigidity of movement. Even if this state of affairs is subtle, it can throw off the accuracy of performance in fine and gross motor skills.
While certification testing must be about proficiency of outcomes, our approach to training is to focus on the process rather than outcome. Selk (2009) says that outcome focus is a perspective that can undermine the success in performance of athletes and others. Process focus keeps the person on-task with his or her mind and body integrated. When the mind gets ahead of one’s body and the action in the situation, he or she becomes vulnerable to skipping steps in the task. As such, the continuity of a step-by-step sequence begins to collapse, which influences task proficiency. When fire-fighting students are prodded by the instructors to concern themselves with speed, the students can become outcome focused when attempting to learn a skill. Moreover, when a student is told that failure to complete the task in the required time can prevent him or her from becoming a firefighter, the outcome stakes become very high. Our experiment examined the difference between (a) an outcome-focused, time-constrained, high-pressure skill drilling with (b) a process-oriented, lower-pressure, and flowing style of practice for improving the speed and accuracy through which fire-fighting students learn to don PPE.

Hypotheses

Based on the literature review, this study tested the following hypothesis: Steady motor training is more effective than high-pressure, high-stress motor training.

\(H_0\): There is no difference in produced skill proficiency between traditional high-pressure PPE turnout drills and relaxed steady-paced PPE donning rehearsal.

\(H_1\): Relaxed steady-paced PPE donning instruction produces increased skill proficiency when compared to traditional high-pressure PPE donning drills.

Methodology

As noted previously, to test this hypothesis a controlled experiment was conducted with two groups comprised of 32 participants in a control group and 30 participants in the test group. The independent variable for our experiment was the teaching style by which individuals were trained in donning their PPE. The control group was taught using the paramilitary method that stresses high-pressure, high-stress motor-training conditions currently used in many fire academies. The test group was taught using rhythmic, steady motor training. The dependent variable was the performance proficiency test of the certification standard for donning the gear in 45 seconds with no errors (skill mastery).

We used convenience sampling of university students to obtain our sample of 62 participants. Because recruit academy training works with mostly college students that are roughly 18 to 30 years of age, it was important that both of our groups were comprised of individuals within that age range. Participants were recruited from the UVU campus, the surrounding community, and our beginning emergency medical technician (EMT) courses. Because the study examines performance proficiencies acquired through training, we excluded volunteers who had prior training in donning fire-fighting PPE. Because of the physical requirements of the study, volunteers with medical conditions, as determined by the review of consent forms, were excluded from participating. Participants were subdivided into manageable learning-group sizes of 10 to 15 members.

Study participants were fitted with PPE supplied by UVU. The gear consisted of (1) one fire-approved helmet with face shield; (2) a flame-resistant overcoat donned with hooks and Velcro®; (3) fire-resistant trousers with suspenders, again attached by Velcro® and hooks; (4) fire-protective gloves and hood, and (5) rubber steel-toed fire boots. The study leaders taught the study participants (firefighters-to-be) how to put on their PPE by donning their own PPE, explaining each piece and enclosure so that the learners could do it correctly. Then the study participants practiced donning the gear with the instructors, who either ordered them to go faster and mentioned push-ups for punishment (the control group), or they were encouraged to relax, take their time, and let the skill improve with repetition (test group).

Groups were trained for approximately one hour and tested for skill proficiency. Study leaders recorded for each study participant the time taken to fully don the PPE and the amount of mistakes he or she made within that time. However, the standard required no mistakes and completion in 45 seconds or less. Therefore, any mistakes theoretically meant the time kept running, even though a participant may have believed he or she had completed the skill accurately.

Our data-collection instrument was a skill-proficiency sheet listing the required steps to don PPE according to the certification standard. Each participant was observed by a study leader who timed the test and recorded each completed step in the PPE donning test. The researcher stopped the time when the participant clapped his or her hands signaling that he or she believed the skill was complete. The required steps were (1) don fire-resistant hood, (2) don and fasten all closures on pants/boots and coat, (3) turn up collar on coat, (4) don helmet and tighten chin strap, and (5) don fire-fighting gloves. If the individual being tested did not complete one of these five tasks, it was considered a failure of the test. The researcher examined the participant’s PPE to check for unclasped enclosures, gaps between garments where they were designed to overlap, and garments that had not been donned. The observations were recorded with the time on the skill-proficiency sheet. Binary designations of pass or fail from these sheets were entered into Statistical Package for Social Sciences (SPSS) statistics software for analysis.

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Data Analysis

Figures 1 through 3 show the data for both the test and control groups. Figure 1 provides a breakdown of individuals in the test and control groups who passed or failed the Utah state standard in regards to the time it took them to completely don their PPE. As the data indicate, 19 passed and 11 failed the PPE turnout drill among study participants using the rhythmic steady motor training (i.e., the test group). Comparable figures for the control group using the high-pressure paramilitary method were 17 individuals passed and 15 failed.

Figure 1: Pass/Fail Rate of the Utah State PPE Turnout Drill for Test and Control Groups.

Two different methods were used to analyze study data. The first method was a z-score test using individuals' times in both the test and the control groups. Given that this was a left-sided test, the z-score had to be less than –Z alpha (which in this case was -0.05) to show a statistically significant difference between the two groups and thus allow the study researchers to reject the null hypothesis. The null hypothesis stated that there is no difference between traditional paramilitary, high-pressure PPE donning drill instruction and relaxed, steady-paced PPE donning instruction. The null hypothesis could be expanded further because time is directly dependent upon an individual's ability to
pass Utah’s state standard for firefighters by completing each step of the exercise. The calculated z-score for the time was -1.645. Based on individuals' time (and their pass/fail rate), the data showed that there was no statistically significant evidence to reject the null hypothesis. However, each individual’s time was stopped when he or she believed that the task had been completed according to the standard. Our calculation of mistakes indicates that not all who believed they had made the time actually did so due to errors in their performance.

The second method used to analyze the data was the Fisher’s Exact Test, which analyzes the statistical difference between the mistakes made by both the control and test groups. Mistakes, however, are interesting in the fact that they directly determine skill mastery. In other words, the amount of mistakes made directly indicates the degree of deficiency for a skill requiring mastery. Therefore, one mistake was a failure to demonstrate proficiency but multiple mistakes indicated lower degrees of deficiency as they accumulated. When testing for differences in mistakes between the test and control groups, our results showed a p-value of 0.0000051. This p-value is below 0.05, which indicates that there is a statistically significant difference in mistakes made between test- and control-group members. Based on this finding, we can reject the null hypothesis. In other words, the data shown suggest that argentic steady motor training is a better method of teaching the skill of donning structural fire-fighting gear.

**Discussion**

In general, from a pure numerical point of view (see Figures 1 though 3), the test group seemed to outperform the control group in both the PPE donning speed rate and in skill mastery, but statistically speaking our test group only showed higher skill mastery. Because study researchers stopped PPE drill time based on a student indicating he or she believed the task had been completed, completion times do not necessarily reflect a passing of the skill. In other words, a student could believe that he or she had successfully donned the PPE when in reality he or she had actually forgotten or insufficiently donned the safety equipment. We believe the state of affairs supports the old adage that haste makes waste in the sense that students leave themselves vulnerable to injury and possible death by donning gear in a rapid but deficient manner. Perhaps over time such errors in donning gear would be corrected with more and more practice. However, as fire-fighting instructors and/or researchers, we believe that mastery first and speed second should be the order of priorities in fire psychomotor-skills acquisition.

The control group used in the study was based on the need for building high-stress, high-stake consequences so as to sufficiently test the hypothesis of whether the paramilitary teaching/learning environment is beneficial or not. However, due to the study-recruitment process, that study participants were told that they were participating in an experiment, and that volunteers were used, clearly we were limited in the level of the stressors we could introduce. In contrast, in the real world fire-fighting recruits candidates who wish to become firefighters as their terminal objective must successfully complete the PPE basic-training drill and receive certification. Without the high-stakes consequences of getting dismissed from the academy and excluded from continuing, the anxiety for the control group was likely less than genuine.

The experiment provided no ethical or practical way that we could have simulated the testing to have genuine high-stakes testing anxiety as a part of the study. In short, a limitation to this study is that real firefighter candidates under high-pressure training may have a cumulative effect of high-stakes testing anxiety, peer social pressure, and the aversion to failing. On the other hand, we can say that real recruits in high-stakes situations would benefit from having the performance and social anxiety dimensions moderated through a less-pressured learning environment. Therefore, our results show that skill proficiency is met more often through mind-body integrated methods of practice without added pressures by the staff, but we cannot account for a student’s own test anxieties and social anxieties in the context of a real academy. Evidence presented here supports the idea that Tai Chi style teaching is still more efficacious while being less impacting on the recruit’s sense of self-efficacy and self-concept as an emerging firefighter. Furthermore, based on the statistical data analyzed, Tai Chi may, in fact, be the better alternative simply because it has shown to increase skill proficiency. Perhaps incumbent firefighters who use the mind-body integration (Tai Chi) style of skills practice might polish and improve their own skill proficiency in both accuracy and efficiency. Test-retest experiments using incumbent firefighters can help answer this question.

From a historical standpoint, high-pressure paramilitary style training is intended to psychologically and emotionally inoculate recruits from stress and help them build coping abilities and focus under pressure. In lay terms, this type of teaching is meant to toughen them up for the real world of fire fighting. In some cases, academy staff may be found to deride, insult, challenge, and intimidate recruits with the intentions of turning up the heat. In the present study, we did not employ any of these tactics for ethical reasons. Moreover, we do not believe such tactics are appropriate teaching tools. However, the fire service is full of anecdotal stories of autocratic and even bullying staff in basic-training programs. We believe our results show this approach undermines student success.
Perhaps teaching mental skills apart from psychomotor fire-fighting skills is a better approach. Teaching people to cope emotionally while trying to learn a new psychomotor skill might be too much. There may be individuals who are excluded from fire-service careers based on not doing well in developing mental/emotional resilience while at the same time performing motor learning to increase physical coordination. Historically, in the fire service there may have been needless exclusion of candidates who would have otherwise done fine without the ceremonial high-pressure traditions. We suggest that the skills be acquired first to the level of mastery and then introduce a high-pressure environment.

**Study Limitations**

We firmly believe that this study has significant implications for fire-service training in general. However, we also recognize that performing such skills in a controlled environment is likely to limit the study’s ecological validity. The rapidly changing and serious nature of real fire scenes does not allow firefighters the opportunities for mistakes that our experimental design provided them. On the other hand, that is exactly why firefighters must first attend training academies for instruction before they are allowed on the fireground.

Experiment participants were drawn from the student body of a university. As such, the generalizability of the results is limited to college students learning how to don PPE using two different instructional methods. Findings might be different for a different learner demographic. For example, adult learners who have had intense and pressured life experiences may have developed coping mechanisms that would aid them in skills acquisition using high-stress instructional techniques. However, we believe that using research participants in the environment of the actual Utah Fire and Rescue Academy and using standard-issued firefighter equipment provided a sufficient degree of real-world simulation to a typical academy-training environment. The study was also limited owing to the duration of practice time that participants were given to mastering PPE donning skills. Perhaps with hours of practice using the traditional paramilitary method or the steady rhythmic style, the statistical differences we found in the experiment would disappear. Overall, however, we believe that the results reported here are useable outside of the experimental context we created, and we urge others to replicate the study.

**Conclusion**

The purpose of this study was to test the hypothesis that steady psychomotor training is more effective than high-pressure, high-stress motor instruction when used to teach firefighters the skills required to successfully don their PPE. Data analysis showed support for this hypothesis. These findings could affect the fire community and the way fire academies instruct new recruits. Additional studies are needed to strengthen the case for Tài Chí style psychomotor training.

Overall, the purpose of standardized testing is to determine whether a fire recruit meets the minimum standard of proficiency, which requires that he or she efficiently perform each step of the task correctly. In the real world, the aspirational standard is for firefighters to do their work as efficiently and effectively as possible in an emergency context. While we believe there is a time and place for high-pressure simulation exercises, there is also a place in firefighter training that allows recruits to learn how to use their PPE and other tools in such a way that creates a greater degree of coordination in manually manipulating these resources for safer and more effective work.

**References**


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