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TSAC RESEARCH REVIEW

This article is the fifth in a continuing series of tactical strength and conditioning (TSAC) research reviews. It is designed to bring awareness to new research findings of relevance to tactical strength and conditioning communities.

COMPARISON OF A LOAD CARRIAGE VEST VERSUS EQUIPMENT BELT FOR USE BY POLICE OFFICERS

In a recent research report, Nerrolyn Ramstrand and colleagues noted the increasing requirement for police officers to wear ballistic protection vests while also carrying their key equipment in some way (7). On this basis, Ramstrand and colleagues decided to compare the biomechanical effects and officer preferences for load carriage vests and standard issue equipment belts, when each was used in conjunction with a ballistic protection vest. In addition, they compared both of these equipment configurations to a situation where the officers wore no vest or belt at all, in order to determine what impact the vests and belt had on movement, comfort, and injury risk. Given the load-bearing vest was something to which the officers were unaccustomed, the research team also reassessed biomechanical impacts and officer preferences after three months of routine use.

Both equipment configurations forced the officers to carry their arms farther out to their sides than they would have carried them if not wearing the vest or belt (7). Both the belt and load-bearing vest limited hip rotation range of movement (7). In addition, the load-bearing vest initially reduced trunk rotation and other aspects of hip and pelvis motion. However, these changes appear to be partly due to the officers being unaccustomed to wearing the vest, as these additional restrictions in motion were reduced after three months of routinely wearing the load-bearing vest (7).

Despite the movement restrictions associated with wearing the load-bearing vest, 55% of the officers (six men and four women) expressed a preference to continue wearing the load-bearing vest and a further 11% (two women) were undecided (7). One third of both the men and women indicated that they would not like to continue to use the load-bearing vest (1). Ramstrand and colleagues further noted that the majority of officers reported greater comfort when using the load-bearing vest instead of the equipment belt for standing, walking, and sitting in work vehicles (7). Interestingly, the majority of officers also perceived their range of motion to be greater in the load-bearing vest than when using the belt (7).

Overall, these results indicate that load-bearing vests may be a viable alternative to equipment belts for police officers. However, there would appear to be no clear superiority of one of these load-carrying configurations over the other, in terms of either comfort or tactical mobility. For this reason, Ramstrand and colleagues recommend that police officers be allowed to choose their preferred load-carriage configuration, if both options are available (7). For the tactical facilitator, these findings may provide a useful basis for advising command personnel and police officers. In addition, it is likely that the load-carriage configuration used by each officer should be considered when tailoring physical training to the individual officer. In particular, it would appear that those using a load-bearing vest for the first time will require time to become accustomed to wearing this configuration. It may be useful to introduce any new equipment gradually so that the body has time to become conditioned to the new load-carriage configuration; thus, potentially reducing the risk of musculoskeletal overload and injury.

BIOMECHANICAL RESPONSES IN MALES AND FEMALES CARRYING A 22-KG LOAD ARE SIMILAR, BUT BODYWEIGHT AFFECTS BIOMECHANICS

Recently, Rebecca Krupenevich and colleagues conducted a novel study comparing biomechanical responses of young adult males and females (11 of each; mostly Army Reserves with load carriage experience) when carrying a standard 22-kg load in a rucksack (3). The authors note that what made this study novel is that previous gender-comparative biomechanical research has generally adjusted loads based on bodyweight, so that the loads have been relative loads rather than the same load for everyone (3).

The main difference between the male and female participants when they were carrying the 22-kg load was that, on average, the female participants adopted a four-degree greater forward lean of the trunk (3). However, further analysis revealed that this difference seemed to be primarily due to average differences between the genders in bodyweight, since for all participants, regardless of gender, lower bodyweight was associated with a similar, greater degree of trunk forward lean (3). This is therefore not really a gender-related difference, but rather a bodyweight related difference, irrespective of gender.

Those with a lower bodyweight and associated greater trunk forward lean (regardless of gender) also exhibited lower ground reaction forces (3). This finding suggests that lighter participants carrying a fixed load may compensate for the greater relative load and the typically lower absolute leg strength by leaning forward more at the trunk. It appears this change in trunk position may help to better counterbalance the load and therefore minimize the forces that must be generated by the back muscles to stabilize the trunk (3). The downside of this increase in trunk forward lean may be increased stresses on some of the structures of the lower back (3). It would seem conceivable that if the increased forward lean simply counterbalanced the greater relative loads, extensor forces required to be generated by the muscles of the lower back and associated stresses on these muscles may not be substantially increased.

For the tactical facilitator, these results suggest that a slightly greater forward lean of the trunk in lighter personnel when carrying fixed loads may be useful and adaptive, and does not necessarily need to be "corrected." Key considerations may be ensuring that the loads are not excessive relative to bodyweight and that the trunk-stabilizing musculature is well developed for sustained stabilization of the trunk and load during load carriage. Additionally, leg strength for sustained load carriage should continue to be developed. Load carriage specific training guidelines have been previously published and may provide useful guidance in these regards (4).

UPHILL LOAD CARRIAGE IS STRESSFUL, FATIGUING, AND ASSOCIATED WITH IMMUNOSUPPRESSION

Sohini Paul and colleagues have recently reported a study involving 12 healthy Indian infantry soldiers. This study investigated changes in biomarkers of stress and immunosuppression during 36 min of uphill load carriage on an incremental gradient, with the gradient progressively increasing from 0 – 25% (5). They conducted multiple trials with each participant, at speeds of 2.5 kilometers per hour (kph) (~1.5 miles per hour [mph]) and 4.0 kph (~2.5 mph), and with loads between 0 – 21.4 kg. Within the 36 min of the load-carriage activity, the participants reached average heart rates close to 190 beats per minute (bpm) and a maximal oxygen uptake (VO_2) close to 53 mL/kg/min when walking at 4.0 kph with the heaviest load (21.4 kg) and having traversed the steepest gradient (25%) for six minutes (5).

Building on the scant previous research of this nature in military cohorts, Paul and colleagues assessed changes in salivary cortisol and immunoglobulin A (IgA) levels following the load carriage activities. Cortisol levels, which are indicative of stress levels, increased steadily with load and walking speed (5). It is also worth noting that cortisol levels were significantly raised post activity even when the walking speed was 2.5 kph and no load was carried, indicating that the uphill walk alone was sufficient to cause a stress response (5). The IgA levels, which are indicative of the respiratory tract's immune capacity, reduced significantly post activity, even when the soldiers walked at 2.5 kph with no load (5). The observed reduction was even greater under load and at faster walking speeds (5). The authors note this temporary immunosuppression in the respiratory tract caused by the load-carriage activities may lead to, and explain, the often reported increased occurrence of upper respiratory tract infections following arduous exercise (5).

For the tactical facilitator, these findings point to the need to ensure tactical athletes are properly conditioned for load carriage, which can be done by using an appropriate load carriage conditioning program. It also suggests avoiding excessive workloads in load carriage, relative to current conditioning levels. While there is no evidence yet to suggest that such conditioning will be protective against stress and immunosuppression during and following load carriage, it is worth noting that the greatest levels of stress and immunosuppression in this study appeared when heart rate and VO_2 were the greatest (5). In addition, previous research has shown a significant association between low levels of aerobic fitness and presentation to health services due to poor health in soldiers (8). On this basis, any improvements in the level of conditioning and physiological efficiencies gained from adequate conditioning for load carriage might be expected to be protective against stress and immunosuppression. Load carriage specific training guidelines have been previously published and may provide useful guidance in these regards (4).

LEGALLY DEFENSIBLE, GENDER-FREE, PRACTICAL, AND ROLE-RELATED PHYSICAL EMPLOYMENT STANDARDS FOR FIRE AND RESCUE PERSONNEL

Sam Blacker and colleagues have recently reported an evidence-based approach used to develop legally defensible, gender-free, practical, and role-related physical employment standards for fire and rescue personnel in the United Kingdom (2). Their work on this project was conducted between 2002 and 2005, and provides a useful example of a well-developed approach that can be used to develop such defensible physical employment standards. Though the entire article is well worth reading, perhaps of greatest interest to the tactical facilitator is the overview of the basis for the physical employment standards that were developed and details of the physical employment standards themselves. Both of these may be of use to tactical facilitators when designing physical training programs.

Blacker and colleagues note that the physical employment standards and associated tests were developed by a rigorous process that began with the team consulting widely with fire and rescue personnel, policy-makers, and technical experts via multiple workshops and a panel of subject matter experts (SMEs) (2). During the consultation, key physically demanding tasks required of fire and rescue personnel were identified. From the key task list, "criterion" tasks and tests were identified and developed, such that personnel who could pass these tests to an appropriate level would conceivably be able to effectively withstand the rigors of fire and rescue service roles. Selection tests were then developed such that the selection tests addressed key elements of the criterion tests, were representative of real aspects of fire and rescue roles, were predictive of performance on the criterion tests, and were practical to implement. Finally, minimum performance standards were developed for each selection test, based on the identified and measured physical demands of the job. This rigorous process focused on actual job tasks and physical demands of those tasks. It did not consider gender, making the resultant selection tests legally defensible and credible for fire and rescue personnel by ensuring that only personnel who can meet the minimum standards could be selected and retained. The tests also provide an effective means of identifying specific requirements for remedial physical training and for assessing readiness to return to work following injury or time away from work.

The selection tests that were designed may provide a useful guide for tactical facilitators who are assessing the physical capabilities of fire and rescue personnel. The selection tests developed by this process for fire and rescue personnel were as follows (2):

- **Rural Fire**: Timed 25-m hose drag (15 kg), jog back 25 m, 100-m hose carry (2 x 15 kg), run out hose 25 m, jog back 75 m, 100-m hose (12 kg) and basket (4.4 kg) carry, jog back 100 m, and 100-m light portable pump simulator carry (33 kg) [passing scores: A=337 s, B=347 s, and C=356 s]
- **Domestic Fire**: Timed 55-kg casualty drag for 30 m walking backwards with 90 degree turns (x 2) [passing scores: A=37.4 s, B=41.3 s, and C=44.3 s]
- **Ladder Lift**: Raise free end of a pivoted ladder arm (13.5 m, 26 kg) from 75 cm to 182 cm off the ground and lower again; load lifted at the lifting point will be increased 4 kg at the lifting point after every successful lift, with 60 s rest between lifts, until a maximum load of 30 kg on the cradle has been added to the simulator [passing score: 30 kg]
- **Ladder Extension**: Raise 62 kg (90% of load required to extend a 13.5-m ladder from the first to second floor) by pulling through 4.5 m of line, and lower (using a PowerSport Tallescope) [passing scores: A=16.5/17.4 s, B=17.9/18.9 s, and C=18.9/20.0 s]
- **Ladder Climb**: Ascend a fully extended 13.5-m ladder to two-thirds of height, take a leg lock, remove hands from ladder, and look down to assessor to identify a symbol placed flat on the ground at the foot of the ladder [pass/fail]
- **Pump Assembly**: Assemble and disassemble Porta Power unit following color-coded diagrams provided [passing scores: A=283 s, B=308 s, and C=328 s]
- **Enclosed Space**: Negotiate 80 cm^3 crawlway containing eight obstacles while wearing a breathing apparatus face mask (no cylinder) with clear vision and return in the same route with vision obscured [passing scores: A=383 s, B=433 s, and C=472 s]

Further details of these tests can be found in the published article. These tests should obviously be assessed for relevance to the context in which they are being considered for application, and only be conducted by assessors who have been safety-trained for the tasks at hand. Relevance of the tests can be assessed by consultation with local SMEs, particularly experienced local fire and rescue personnel.

LONG WORK SHIFTS IN POLICING: EFFECTS ON OFFICER ATTENTION, PHYSICAL REACTION TIMES, AND SHOOT/NO-SHOOT DECISIONS

Leonard Bell and colleagues recently conducted an experimental study involving two precincts of the Phoenix Police Department (1). The study compared the effects of three days of 13 hr and 20 min work shifts per week to the effects of four days of 10 hr work shifts per week. One precinct (N=189 officers) implemented the three days of 13 hr and 20 min shifts arrangement and another precinct (N=197 officers) implemented the four days of 10 hr shifts arrangement, both over a six-month period. Outcomes for both groups were assessed using a range of health and performance measures. Of particular relevance to the tactical facilitator were the findings on attention, physical reaction times, and shoot/no-shoot decisions.

Physical reaction times and attention were assessed using the computer-based psychomotor vigilance test (PVT). Shoot/no-shoot decision accuracy was assessed using a standard annual pass/fail shooting qualification test. Notably, physical reaction times were approximately 10% slower in law enforcement officers undertaking the longer shifts and this difference persisted throughout the six-month time frame (1). Attention was also impaired, with officers in the long shifts nearly twice as frequently showing lapses in concentration (1). However, reactions prior to receipt of all relevant information occurred 25 – 30% less frequently in officers on the longer shifts, while shoot/no-shoot decisions were similarly accurate between the two groups.

Firstly, these findings indicate that the tactical facilitator can benefit from knowledge of the duration of the work shifts of law enforcement personnel they train. Those undertaking longer shifts may require special consideration to ensure their safety when undertaking physical training, due to their impaired reaction times and the increased lapses in concentration that are associated with longer work shifts. For example, this may mean conducting physical training with such personnel on more even terrain and avoiding rapid training that depends on fast reaction times and high levels of concentration.

Secondly, even when they are fatigued due to longer shifts, law enforcement officers continue to make similar shoot/no-shoot decisions to those working shorter shifts. In addition, there is no indication that those on longer shifts react prematurely (i.e., before all relevant information is available to them) any more often than those who are less fatigued. When serious decisions are to be made, it appears that even tired law enforcement officers take time and ensure their decisions are the right ones in the circumstances.

AGE-RELATED DIFFERENCES IN FIREFIGHTER BMI, STRENGTH, AND POWER

In a recent study involving 229 Italian male firefighters, Fabrizio Perroni and colleagues examined differences between age groups in body mass index (BMI), upper body strength, and leg power (6). Upper body strength was assessed by a one-repetition maximum (1RM) bench press and leg power was assessed by both counter-movement jump (CMJ) height and 20-m sprint time.

Not surprisingly, all measures worsened as age increased. Comparing the highest and lowest age groups, average BMI was 1.8 kg/m^2 higher in those aged over 45 years than in those aged 30 or less, but for both groups, the average remained within the healthy range (6). On average, the above 45 years old age group were able to lift 12% less weight on the bench press than the 30 or less age group, though the authors note that the weights lifted by the older age group remained higher than those previously observed in novice firefighters (6). CMJ height was 13% less, on average, in the above 45 years old age group than in the 30 or less age group (6). Additionally, the 20-m sprint times were just 5% slower in the above 45 years old age group than in the 30 or less age group (6).

These results indicate that a small decline may occur in upper body strength and leg power and a small increase in BMI as age increases in firefighters. It is notable, however, that even the oldest firefighters in this study remained relatively fit and strong. For the tactical facilitator, these results provide insights into some of the aspects of strength and conditioning that are adversely affected by age and therefore should be targeted in tailored training programs. The results reveal that the average changes observed to accompany the advancement of age were relatively small, suggesting that firefighters typically maintain strength and fitness quite well as they age. Therefore, tactical facilitators may only need to make small adjustments in training to account for aging.

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