Load carriage for the tactical operator: Impacts and conditioning - A review

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PEER REVIEW - TSACA
LOAD CARRIAGE FOR THE TACTICAL OPERATOR: IMPACTS AND CONDITIONING - A REVIEW.

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BOTTOM LINE UP FRONT
For the tactical operator, conditioning to increase and maintain load carriage resilience forms an essential risk management strategy through which the negative impacts of load carriage can be managed and essentially reduced.

ABSTRACT
Tactical operators are required to carry loads as part of their occupations. Carriage of these loads have been associated with causing physical injuries to the carrier and impairing their ability to perform occupational tasks. One potential means of negating these risks associated with load carriage tasks is through physically conditioning the carrier. Through use of the Frequency, Intensity, Time and Type (F.I.T.T.) formula this review explored the literature to determine the optimal conditioning stimulus to enhance the resilience of tactical operators required to perform load carriage tasks. It was determined that a conditioning stimulus of one load carriage session every 7 to 14 days is required. While the intensity of the load carriage session (load weight, speed of march, terrain grade and type) has the potential to provide a greater training effect than the length of the session (time), both parameters must progress to meet occupational requirements. In general, load carriage-specific training is preferred, with the training effect increased by field exercises that included load carriage tasks. Furthermore, a combined approach of progressive resistance training (especially for the upper body) and aerobic conditioning three times per week is of value. The outcome of this review provides the tactical strength and conditioning coach with an optimal training dose for load carriage conditioning.

Key Words - Load, carriage, conditioning, training, tactical, soldier.

INTRODUCTION
Tactical operators, be they law enforcement officers (4), fire-fighters (31), or military personnel (26), are required to carry loads as part of their occupation. These occupational loads can constitute tools and stores required for protection (e.g. weapon systems, body armour, fire retardant clothing), sustainment (e.g. water, food, oxygen) and task performance (e.g. breaching devices, fire hoses). Carried on the head (e.g. helmet, night vision devices), back (e.g. backpack, self-contained breathing apparatus), hands (e.g. weapon systems, axes), thigh (e.g. side arm, gas mask) or feet (e.g. boots), the combined weights of these loads have seen general duties police officers carry up to 7 kg (10), fire fighters up to 37 kg (39), and Australian Army soldiers up to an average of 48 kg (25) into unpredictable and hostile environments.

Carrying heavy load is known to place stress on the musculoskeletal system of the carrier (8), and has been associated with causing physical injuries (14, 27) and even mortalities in previous conflicts (18). Injuries to the load carrier can range from blisters and foot, ankle, knee and back pain, to stress fractures and neurological conditions like brachial plexus palsy and meralgia paraesthetica (27). Not only may these injuries reduce the size of a workforce available for tasks, but they may potentially increase the chance of injury to non-injured personnel through increasing their workload to compensate for absent members.

Apart from injuries, load carriage has been found to impact on the performance of tactical tasks, including mobility, lethality and attention to task (27). The impacts of load carriage on mobility are diverse. In a general sense, research has observed that load carriage increases the time taken for the carrier to move a given distance. Soldiers have been found to take significantly longer moving between checkpoints (19% slower with 14kg load; 44% slower with 41 kg load) (30), crossing obstacles (12-26% slower with the same loads respectively) (30), and conducting break contact drills (32% slower with a load of 26 kg) (16). This in turn increases the soldier’s exposure to hostile fire. For the fire fighter, research has demonstrated a significant reduction in a fire fighter’s ability to step over obstacles successfully while carrying their occupational loads (31). This in turn increases their risk of tripping or falling while performing firefighting duties. In the wilderness, the time taken by fire fighters to transit emergency escape routes have also been shown to increase in turn increasing their risk of injury or mortality (35). Police officers report similar mobility limitations with general duty appointment belts known to restrict movement (especially in vehicles) (10).

In addition to reducing mobility, load weight has been observed to reduce soldier lethality in many, but not all cases (24). Rifle marksmanship and grenade throw for distance have both been observed to decrease as carried load weight increases (24, 27). When considered in conjunction with limitations in mobility and the performance of fire-and-
movement drills while in contact with the enemy, these limitations of mobility and lethality increases the bounding soldier’s exposure to enemy fire with each bound taking longer and lethality less effective in suppressing the enemy.

Alertness (11) and the ability to pay attention to tasks (17, 19) have likewise been found to be significantly impaired by load carriage tasks (p<.01; p<.05 respectively). In particular, attention to visual stimuli has been found to be reduced to a greater extent than attention to an auditory stimulus (19). For a soldier this can translate to a reduced ability to identify improvised explosive devices, for a police officer, the ability to notice a hidden weapon and for the fire fighter, the ability to notice potential weakened structures or patterns in fire movement.

While reducing the load weight to be carried presents as one option for addressing the injuries and performance impairments associated with load carriage tasks, research suggests that load weights, particularity those borne by soldiers, are increasing (26). This is not surprising given that battlefield technology can often have countervailing effects, with loads reduced in one area only to be returned in another (3, 20, 29). An alternative option is to physically condition the tactical operator to carry loads. This concept is not new and has been employed by warriors of antiquity (26). However, if load carriage is to reduce rather than cause injuries, the conditioning process must be carefully structured. The purpose of this review was to determine the optimal load carriage conditioning platform for the tactical operator.

METHODS

To identify papers that may inform this review, the Summon® service was selected. Apart from the capture of articles from various databases, this tool allows for the data capture of potential grey materials (like government reports). Employing Boolean search operators, search terms ‘load’ AND ‘carriage’ AND ‘physical conditioning’ OR ‘physical training’ were used. Due to the progressive nature of physical conditioning education and practices, search parameters were restricted to the most recent 10-year period (November 2002 to present). Search exclusion criteria included: (1) studies not published in English, (2) aged groups (e.g. geriatric, paediatric), (3) medical conditions (e.g. diabetes, obesity), (4) non-human subjects (e.g. horses, rodents), and (5) medical specialties (e.g. oncology, neurology, psychology). Captured journal articles were then subjected to the following inclusion criteria: (1) papers were peer-reviewed, and (2) papers reviewed load carriage conditioning practices.

From an initial 45 search results, a total of three articles met the inclusion criteria. These articles were: a narrative review (28), a systematic review (13) and a general load carriage review which included a section specifically addressing load carriage (14).

DISCUSSION

The F.I.T.T. (Frequency, Intensity, Time and Type of training) formula was selected as the framework through which to discuss the findings for three reasons. First, the principle provides a common framework for describing a physical conditioning training dose (2, 5, 21) and is used by the American College of Sports Medicine (ACSM) to detail the training requirements for health (5, 9, 40). Second, this principle is commonly used by military and policing physical training instructors / fitness advisors to develop and describe physical conditioning programs. Third, the principle has been used in other research fields to discuss physical conditioning standards and requirements (7, 22).

Frequency

A load carriage conditioning session conducted every 7- to 14-days was considered as optimal and found to present larger training effects than training less frequently. Training less frequently, being a frequency of longer than a 14-day period between conditioning sessions, was noted as limiting load carriage conditioning. This finding is not surprising given the principle of reversibility which suggests that following cessation of training, an individual’s body ‘detrains’ over a period of time to a level of fitness consistent with the current lower work rate (40). This principle is supported by research demonstrating a decrease in aerobic fitness measures following periods of training cessation (6, 23). Furthermore, a study by Knapik et al. noted the potential for load carriage injuries to increase in soldiers who had no recent load march training (15).

While no research presented explored load carriage conditioning frequencies of greater than one session every 7 days, the load carrier is still subject to the principle of recovery. The principle of recovery highlights the need for the systems of the body to have a sufficient recovery from the training stimulus to prevent overload and injury and allow positive adaptation (34). Failure to provide recovery in the training program and to instead employ high volumes of vigorous weight-bearing activities continuously has been identified as a causal factor in high injury rates among military personnel (32). Considering this however, tactical operators may often be required to carry loads for several days in succession. As such, aligning the frequency of this training with training intensity is of importance (28) as lighter loads (intensity) may be tolerated more frequently once the body has been conditioned to sustain the load. Finally, as these populations will seldom complete a load carriage conditioning program in isolation, consideration must be given to the other conditioning and training activities that the tactical operator is subject to during the conditioning cycle.
Intensity

Increases in load weight, speed of movement, and the grade of terrain incline have all been found to increase the energy cost of carrying load as has different types of terrains (14). As such, all four of these contextual factors can constitute a measure of intensity in the load carriage conditioning context. For instance, an increase in speed of march by 0.5 km/h or an increase in incline traversed of 1% have been considered to increase the energy cost of carrying load to the same extent as an increase in load weight of 10 kg (37). On this basis, increasing the speed of march over a given distance from 5.0 km/h to 5.5 km/h can serve as an increase in intensity as can an addition of pack load weight.

Only the review by Orr et al. (28) directly considered the impact of intensity for load carriage conditioning, with the research suggesting that load carriage intensity is of more importance than load carriage frequency (1 versus 2 times per fortnight) (38) or duration (shorter versus longer sessions) (36, 38) in regards to improving aerobic capacity and loaded march performance. Ultimately, it is proposed that the intensity of the load carriage conditioning sessions must be gradually increased and progressed to meet occupational requirements (see Table 1 and Figure 1). For a soldier, this could be carrying load weights commensurate with operational requirements at a structured patrol pace over the terrain grade and type typical of their operational environment. Likewise, for the fire fighter, the primary nature of their tasks would form the key focus, metropolitan versus rural operations as an example. General policing duties, which could entail long duration foot patrols at an intermittent pace with a utility belt or chest rig and accoutrements, would likewise differ from specialist response officers who may be required to perform explosive tasks with greater load weights through bush lands or office buildings.

**Table 1 - An example of a 12-week periodised load carriage program for a military tactical operator.**

<table>
<thead>
<tr>
<th>Session</th>
<th>Dose</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1 Monday</td>
<td>15 kg in Patrol order without Weapon; 20 minute long continuous session; Speed ranging from 5.0-6.0 km hour; Across open country with low undulating hills.</td>
<td></td>
</tr>
<tr>
<td>Week 2 Monday</td>
<td>15 kg in Patrol order without Weapon; 25 minute long continuous session; Speed ranging from 5.0-6.0 km hour; Across open country with low undulating hills.</td>
<td>Introduce basic obstacles (10 minutes)</td>
</tr>
<tr>
<td>Week 3 Monday</td>
<td>15 kg in Patrol order with Weapon (5 kg); 20 minutes long continuous session with 5 minutes of intro to shuffle running; Speed ranging from 5.0-6.0 km hour; Across open country with low undulating hills.</td>
<td>Introduce weapon carriage Revise obstacles</td>
</tr>
<tr>
<td>Week 4 Monday</td>
<td>15 kg in Patrol order with Weapon (5 kg); 30 minutes long continuous session with 5 minutes of intro to shuffle running; Speed ranging from 5.0-6.0 km hour; Across open country with low undulating hills.</td>
<td>Continue weapon carriage Introduce slow shuffle between obstacles</td>
</tr>
<tr>
<td>Week 5 Monday</td>
<td>15 kg in Patrol order with Weapon (or mock weapon) plus 1/4 of 40 kg stretcher; 20 minutes; Speed ranging from 5.0-6.0 km hour; Across open country with low undulating hills.</td>
<td>7.5 Minutes continuous session with 2.5 minutes of fire and movement, 10 minutes with stretcher</td>
</tr>
<tr>
<td>Week 6 Monday</td>
<td>10 kg in Patrol order with Weapon; 15 Minute / 2.4 km; Speed 9.6 km hour; Across open country with low undulating hills.</td>
<td>Unload week Run and shoot</td>
</tr>
<tr>
<td>Week 7 Monday</td>
<td>30 kg in Marching (inc Weapon (or mock weapon)); 20 minute long continuous session; Speed ranging from 4.5 - 5.5 km hour; Across open country with low undulating hills.</td>
<td>Introduce to pack marching</td>
</tr>
<tr>
<td>Week 8 Monday</td>
<td>30 kg in Marching Order (inc Weapon); 25 minute long continuous session; Speed ranging from 4.5 - 5.5 km hour; Across open country with low undulating hills.</td>
<td></td>
</tr>
<tr>
<td>Week 9 Monday</td>
<td>25 kg in Patrol order (inc Weapon); 25 minute long continuous session; Speed ranging from 5.0 - 6.0 km hour; Across open country with moderate hills.</td>
<td>Introduce moderate hills 15 kg patrol order with weapon and additional equipment (radio, LAW)</td>
</tr>
<tr>
<td>Week 10 Monday</td>
<td>35 kg in Marching Order (inc Weapon); 25 minute long continuous session; Speed ranging from 5.0 - 6.0 km hour; Across open country with low undulating hills</td>
<td>Drop packs - Patrol order revise Fire and Movement and Stretcher carry (10 mins) No packs - Reinforce obstacle add stretcher (15 mins)</td>
</tr>
<tr>
<td>Week 11 Monday</td>
<td>30 kg in Marching Order (inc Weapon); 35 minute Intermittent session; Speed ranging from 5.0 - 6.0 km hour; Moderate hills.</td>
<td></td>
</tr>
<tr>
<td>Week 12 Wednesday</td>
<td>BATTLE SIM EVENT: 2.5 km Patrol Order March into Area (carrying 35 kg); Contact - Drop packs and Fire and Move &amp; Obstacles in Patrol Order (10 mins); 1 km Patrol Order march with stretcher and stores (10 mins).</td>
<td></td>
</tr>
</tbody>
</table>
Time
Like intensity, the time (or distance) of the load carriage stimulus was only considered in the review by Orr et al (28). As noted above, load carriage session duration was considered to produce a lower training effect than load carriage intensity in regards to improving aerobic capacity and loaded march performance. However, occupational load carriage requirements must still be considered and addressed whether they be predominantly short dynamic actions (neutralising a perpetrator in the police ‘watch house’) or longer duration intermittent or continuous (sustained firefighting actions) tasks. A final, albeit important, point for the tactical operator is that long duration load carriage events are utilised to not only train physical resilience but also the mental stamina to endure long duration tasks (2) (e.g. dismounted foot patrols).

Type
Both reviews highlighted the importance of specificity in load carriage conditioning. The principle of specificity suggests that the conditioning stimulus should approximate the nature of the task (1, 12, 33): a concept which aligns with the concept of the Specific Adaptation to Imposed Demands or SAID principle (1), whereby specific adaptations occur in response to the nature of the conditioning stimulus. Hence, findings that specific load carriage conditioning facilitates a greater training effect than conditioning without specific load carriage sessions are understandable. This training effect is greater still when field training, which includes load carriage tasks, are performed. Furthermore, comments from platoon training staff involved in one of the reviewed studies suggested that soldiers who performed load carriage conditioning training performed better at military tasks than soldiers who were conditioned through running training (36).

Notwithstanding the principle of specificity, other forms of conditioning may be of benefit to a load carriage program. The research available is however conflicting, most notably in strength training or aerobic training in isolation. However, the combination of both a periodised resistance training program and aerobic conditioning program (3 times per week for a minimum of 4 weeks) may indeed produce a substantial training effect on load carriage performance when measured in time to complete a task (13). Furthermore, resistance training that leads to increases in upper body strength and endurance has been suggested as being of greater benefit than training for the lower limbs in regards to load carriage performance (13). The role of the upper body in supporting load carriage systems (e.g. backpack straps) and stabilising the upper body during load carriage tasks presents as a viable reason for this finding (13).

CONCLUSIONS AND PRACTICAL APPLICATIONS
For the tactical operator, conditioning to increase and maintain load carriage resilience forms an essential risk management strategy through which the negative impacts of load carriage can be managed and essentially reduced. For the Tactical Strength and Conditioning Coach optimal load carriage conditioning of tactical personnel would include:
• Frequency: A minimum of one specific load carriage activity every 7 to 14 days, noting that further research is needed to investigate the benefits and impacts of conducting more than one load carriage specific conditioning session per week. This load carriage activity can be either a specific conditioning session or a field based (on the job) activity. Supplemental load carriage conditioning activities, like resistance training and aerobic (metabolic), should be performed three times per week.

• Intensity: Loads and their associated contexts (speed and terrain) must progress to meet occupational demands. Load weight, speed of march and the terrain types and grades must be manipulated in consideration of session duration (see the example in Table 1 and Figure 1). Progression must take into account the tactical operator’s level of fitness and previous load carriage experience, other physical conditioning sessions during the planned conditioning period, previous injuries and daily occupational requirements.

• Time: The duration or distance of the load carriage conditioning events must likewise progress to meet the demands of the occupational circumstance. However, increases in the time or distance of a load carriage conditioning activity should not be introduced at the same time as an increase in intensity.

• Type: Load carriage conditioning activities in particular should be performed, preferably in the field (on the job) where possible. Supplemental training may be of benefit, most notably a combination of resistance training (especially upper body) and aerobic training (see Table 2).

### Table 2 - An example of a weekly load carriage program for a military tactical operator.

<table>
<thead>
<tr>
<th>Session</th>
<th>Session Type</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>Load Carriage Session</td>
<td>35kg in Marching Order (Inc. Weapon); 25 minute long continuous session;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Speed ranging from 5.0 - 6.0 km hour; Across open country with low</td>
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<tr>
<td></td>
<td></td>
<td>undulating hills.</td>
</tr>
<tr>
<td>Tuesday</td>
<td>Hydro recovery session</td>
<td>Spinal decompression session with revision of basic swim survival skills:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>400 m any survival stroke, tread water for 10 minutes, make a flotation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>device from clothing.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Include Free From Infection skin check – Blisters, rashes etc.)</td>
</tr>
<tr>
<td>Wednesday</td>
<td>METCON Circuit</td>
<td>7 Movement Patterns 5x5: Tyre Flip (Squat), Rope Climb (Pull), Leopard</td>
</tr>
<tr>
<td></td>
<td></td>
<td>crawl push up, pop up (Push) into 10m run (Gait) repeats, Hanging angled</td>
</tr>
<tr>
<td></td>
<td></td>
<td>insteps (Bend &amp; Twist), Alternating Lunge with ground touch (Lunge with</td>
</tr>
<tr>
<td></td>
<td></td>
<td>hip hinge)</td>
</tr>
<tr>
<td>Thursday</td>
<td>High Intensity Interval</td>
<td>Modified Urban Rush: 20m sprint, stop drop, x 5 (1:/0.5) x 8</td>
</tr>
<tr>
<td></td>
<td>Training</td>
<td></td>
</tr>
<tr>
<td>Friday</td>
<td>Heavy Lift, Carry and Move</td>
<td>Weighted Chins, Weighted Dips, Body Drag, Vehicle push, Sledge hammer,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>rope haul.</td>
</tr>
<tr>
<td>Weekend</td>
<td>Rest or Light recovery</td>
<td>Yoga/Pilates/Qi Gong</td>
</tr>
</tbody>
</table>
REFERENCES