Musculoskeletal injuries and dropout in the military

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Training load monitoring and injury prevention in military recruits: Considerations for preparing soldiers to fight sustainably

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Chapter 9

ABSTRACT

Musculoskeletal injuries during basic military training, frequently resulting in dropout, are well-recognized as a substantial problem both logistically and financially. Seven key evidence-informed principles of load management to minimize the risk of injury have been proposed in sport. A pertinent question is whether these principles can also be applied to military recruits with the ultimate aim of reducing the incidence and impact of musculoskeletal injuries and attrition from training. In this review we address the challenges and possibilities of applying load management principles to basic military training and suggest practical applications for military strength and conditioning professionals.
INTRODUCTION

Musculoskeletal injuries (MSIs) frequently result in dropout from basic military training (BMT) and are well-recognized as a substantial socio-economic, logistic and public health problem facing military organizations globally.1,2,3 Overuse injuries are by far the most common injuries sustained by military recruits.4,5 For many undergoing BMT, it is widely believed that the type and volume of the physical load are relatively higher than recruits have previously experienced before BMT and failure to adapt to the increase in training load, increases the risk of MSIs.6,7,8 Across sports, poor training (e.g. internal and/or external) load management is one of many established risk factors of overuse MSIs.9,10 Importantly, routine monitoring of training load can identify athletes who are at increased risk of injury.10 Seven key evidence-informed principles of load management have been proposed in sport to minimize the risk of MSIs.11 The training load monitoring methodology in sport may also provide a template for the military, with the aim to reduce MSIs and dropouts from BMT caused by MSIs.12

Specific military fitness includes being able to carry and transport equipment and ammunition over long distances, being maneuverable and agile regardless of the terrain, and possess exceptional stamina, power and coordination.13 More specifically, the following nine common military tasks are identified: jumping over obstacles, moving with agility, carrying heavy loads, dragging heavy loads, running long distances, moving quickly over short distances, climbing over obstacles, lifting heavy objects and loading equipment.14,15 The physical qualities of muscular strength, power, and endurance are suggested to be critical to accomplishing these tasks.15

BMT is the entry point for the military and forms the basis (i.e. framework) upon which all successive training is based.7,8 BMT courses are designed to develop soldiering skills, army values and lifestyle, and create a framework to convert civilian recruits into operational capable military personnel.3,16 The aim of BMT is the supply of high standard trained soldiers to perform military tasks effectively in versatile situations for the longevity of their military service.17,18 Although the BMT syllabi may differ across countries, in general, military training programs are both physically and mentally arduous by design. The completion of BMT is mandatory for all recruits to progress their career within the military.19,7 Internationally, the length of BMT and the total duration of physical training varies between eight to thirty-nine weeks and four hours per week to two hours per day, respectively, depending on whether infantry and advanced military skills are also covered in the initial course.8,16,18,21,20 Although there is a variation in the eligibility requirements for general health as well as well-being, baseline physical and mental fitness (e.g. endurance and resiliency) must be demonstrated to be accepted into military training of Armed Forces.14,18,22 Nevertheless, recruits enter the military with widely varying fitness levels, even within one platoon.3,23 Also, cultural and contemporary differences may apply across countries and generations. Whether BMT is designed to test and assess suitability
for the concerned Armed Forces, or whether BMT is designed to train, empower and shape sustainable soldiers has a great impact on MSI- and dropout preventive strategies. Also, whether applications are abundant, or the military organization has to deal with many vacancies, impacts the necessity of such strategies.

As mentioned, overuse injuries in military recruits during BMT place a huge logistical and financial burden on military organizations.\(^3,7\) Seven key evidence-informed principles of load management to minimize the risk of MSIs in sport are: (1) establish a moderate chronic load; (2) minimize the week-to-week changes in training load; (3) do not exceed the workload ceiling of safety for the sport; (4) ensure a minimum training load is maintained; (5) avoid inconsistent ‘boom-bust’ workload patterns; (6) ensure training loads are proportionate to the workload demands of the sport; (7) monitor the athlete throughout the latent period.\(^11\) To implement these principles, routine load monitoring is fundamental.\(^10,11\) There are many different measures of load, which are described by Soligard et al.\(^10\) in an International Olympic Committee consensus statement and by Maupin et al.\(^12\) for tactical populations, but it has been stated that no single marker can consistently predict maladaptation or injury.\(^10,12,24,25\) To optimally monitor internal and external load, staff ought to choose tool(s) capable of detecting changes in physical fitness and measuring the level of stress of each training session.\(^10,12,18\) Globally, routine monitoring of internal and external load also in military training is growing.\(^3,12,20,21,23,26,27,28,29\) Notably, efforts to monitor and quantify load is one thing, effectively converting such data into evidence-informed principles and implementing such principles to actually manage injury risk in the target population, is another.

But first, what is exactly meant by monitoring and quantifying training load? External load can be defined as the “amount of work the body has completed”.\(^26\) Measuring external load involves quantifying the physical work performed (e.g. type, time, distance travelled, weight lifted, and repetition counts).\(^24,30\) Also, the influence of external factors such as altitude, humidity and daily hassles and travels need to be taken into account.\(^7,16\) Internal load is a function of an individual’s perception and awareness of the stress experienced during training and recovery.\(^6,31\) Internal load is measured by assessing the internal physiological and psychological response to the external load, such as heart rate, blood lactate concentration, or ratings of perceived exertions (RPE).\(^32\) Most military studies monitor external load by training type, time, frequency, distance, movement repetition counts, and accelerometers, while internal load measures include i.e. session RPE (RPE-score multiplied by session duration), profile of mood states (POMS), heart rate, sleep and biochemical/hormonal assessments (detailed descriptions of training load monitoring in military personnel are for example provided by Austin et al.\(^26\) and Jurvelin et al.\(^23\)). Examples of how training activities during BMT can be converted in to daily and weekly training load are presented in table 1 and table 2. Determining a shared language and common goals among key stakeholders (e.g. commanders, physical trainers, medical personnel, recruits) regarding load monitoring and applying evidence-informed injury
prevention strategies offers a valuable opportunity to minimize MSI risk and attrition from military training. Figure 1 sketches an example of the involved staff and their interactions in educating and training military recruits. Increasing available training data and fostering fruitful cooperation between parties may provide opportunities for timely optimization of training and education to help recruits unlock their potential and prevent dropout from military training.

**Table 1:** Individualized daily training load

<table>
<thead>
<tr>
<th>Day</th>
<th>Exercises</th>
<th>Training duration</th>
<th>Heart rate</th>
<th>Rate of Perceived Effort (RPE)</th>
<th>Session Training Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Loaded foot march</td>
<td>96 minutes</td>
<td>145</td>
<td>8.0</td>
<td>768</td>
</tr>
<tr>
<td></td>
<td>Combatives</td>
<td>50 minutes</td>
<td>130</td>
<td>7.0</td>
<td>350</td>
</tr>
<tr>
<td></td>
<td>Obstacle course</td>
<td>45 minutes</td>
<td>155</td>
<td>7.5</td>
<td>337.5</td>
</tr>
<tr>
<td></td>
<td>Daily Training Load</td>
<td></td>
<td></td>
<td></td>
<td>1,455.5</td>
</tr>
<tr>
<td>2</td>
<td>Run</td>
<td>45 minutes</td>
<td>155</td>
<td>8.5</td>
<td>382.5</td>
</tr>
<tr>
<td></td>
<td>Swim</td>
<td>45 minutes</td>
<td>160</td>
<td>7.5</td>
<td>337.5</td>
</tr>
<tr>
<td></td>
<td>Resistance training</td>
<td>60 minutes</td>
<td>130</td>
<td>8.0</td>
<td>480</td>
</tr>
<tr>
<td></td>
<td>Squat</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dead lift</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shoulder Press</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Daily Training Load</td>
<td></td>
<td></td>
<td></td>
<td>1,200</td>
</tr>
</tbody>
</table>

**Table 2:** Individualized weekly training load

<table>
<thead>
<tr>
<th>Daily Training Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
</tr>
<tr>
<td>Day 2</td>
</tr>
<tr>
<td>Day 3</td>
</tr>
<tr>
<td>Day 4</td>
</tr>
<tr>
<td>Day 5</td>
</tr>
<tr>
<td>Weekly Training Load</td>
</tr>
</tbody>
</table>
Figure 1: Military staff involved in training and education during basic military training

One can debate whether sports athletes and military recruits share some similarities. But it is obvious that both populations strive to achieve high levels of performance, which underpins the need to address the topics in this paper. By approaching military training holistically and viewing BMT as an initial step in the entire process from training civilian recruits into effective military personnel, presumably, the two biggest differences are the operational military tempo compared to the scheduled seasonal structure in sport, and secondly that—after finishing training and involved in combat—the costs of fitness shortcomings are much higher for tactical professionals than for athletes. As such fully trained military personnel are required to respond rapidly and thus the need to be prepared throughout, as opposed to specific off-, pre-competition and competition seasons. And that the worst outcome for a tactical professional is that lives may be lost, and an entire military operation may fail. Moreover, BMT provides a solid foundation for the nine common military tasks as well as to perform tasks effectively in versatile situations. In contrast to the more respective sports specific training prescriptions that are required in sport. Arguably similarities for both sports athletes and military recruits is that performance requires ‘concurrent’ physical and mental strength, endurance and resilience capacity.
In instances where fitness is sub-optimal, BMT will not create life-threatening situations for military recruits. However, from the day recruits enter BMT they are preparing to eventually participate in military operations. Arguably, preparing soldiers to kill rather than develop specific physical qualities poses considerable difficulties when designing an optimal training regime for soldiers compared to athletes. A successful military trainer is able to design a short-term training program to optimize training adaptations and reducing training load error, injuries and attrition, while in the long-term, also developing a service member that is harder to kill and better at killing.

A pertinent question is whether the seven key evidence-informed principles of load management to minimize the risk of MSIs in athletes can also be applied to military recruits with the ultimate aim of reducing the incidence of musculoskeletal injuries and attrition from training. Secondly, are adjustments in these seven key principles required when applied to military recruits? In order to raise awareness and contribute to the body of evidence, we will discuss how the previously published seven injury prevention principles can possibly be applied during basic military training.

**SPORTS INJURY PREVENTION: SEVEN PRINCIPLES OF LOAD MANAGEMENT**

*Establish a moderate chronic load*

A consistent moderate level of training load can be established through routine monitoring and is suggested to be protective against injury. In BMT, physical training is used both to induce physiological adaptations, as well as mental hardiness (the ability to endure difficult conditions), resiliency (the capacity to recover from difficulties), and military culture. The benefits of collective suffering through physical stress, in combination with the various activities in BMT (e.g. running, calisthenics, obstacle course, resistance training, military self-defense, rope climbing, but also loaded (speed) marches and tactical shooting drills) makes BMT likely to elicit large fluctuations in training loads instead of a constant moderate training load.

A possible solution to this challenge may be—while maintaining fitness end standards—individualization of training programs, like the prescription of training for load carriage on an individual basis in line with current physical capacities to refine and optimize training load, based on pre-training measures such as endurance and strength. Sports like High-Intensity Functional Training and CrossFit demonstrate pragmatic methods in which both physical training load is optimized per individual as well as triggering mental processes such as perseverance. Such individualization may be applied through maintaining the length in training but prescribing different training regimes and additional training if needed, or by lengthening the time in training per recruit. However, indeed, individualization of training programs also faces its challenges.
both practically and logistically, of course depending on the nature and volume of the adjustments made. Examples of such challenges are the need for more drill instructors and a higher workload (i.e. more working hours per day) per instructor, increased demand on housing and transporting recruits, increased length in BMT results in higher costs per recruit, and varying lengths in training may result in less group bonding.41

Nevertheless, investing in load monitoring strategies (for example using accelerometers and/or session RPE) and prospectively monitoring military physical performance and the incidence of MSIs may help determine a consistent level of moderate chronic load required for BMT.18 Also, flexible updated guidelines including the frequency, intensity, and distances of loaded marches, speed marching, tactical drills, specified per session, week and BMT as a whole may be valuable to prevent large fluctuations in training load and thereby consciously managing MSI risk.7,13,23

Minimize the week-to-week changes
Large increases in training load may precede injury.7,42 The training load of military tasks and the weekly training load in BMT varies widely.7,8,16,23 It has been observed that MSI rates are relatively high during early weeks of military training possibly suggesting a mismatch between training loads and load capacity.6,7,16 Typically during BMT, the job resources are low (e.g. recruits have low autonomy, and confidence and self-esteem are blunted by training staff), with very high job demands (e.g. fast progression in both military skills as well as physical fitness), resulting in an imbalance between resources and demands and therefore high amounts of stress in recruits.43 Ideally, through gradually increasing physical fitness, without large increases in training load, one of the factors in the job demands can be reduced, theoretically resulting in more appropriate overload and less physiological stress.7,43,44

Through pre-enlistment fitness assessments and by providing physical preparation programs, efforts can be made to establish minimal fitness standards to start military training.17 Prior physical activity levels can be established, and recruits can be categorized into subgroups according to chronic load and baseline physical fitness (maintaining minimal physical fitness standards such as 2400 meter on the Cooper test). Also, training in groups based on risk factors may potentially minimize individual week-to-week changes in training load.18 Collectively, these strategies may reduce the risk of non-functional overreaching or overtraining.7,45

Do not exceed the workload ceiling of safety for the sport
In some sports a “ceiling” effect of training load is observed. For example, if weekly internal loads exceeded 5000 arbitrary units (session RPE multiplied by session duration), the risk of injury was significantly increased.46 The “ceiling of safety” has also been observed for external loads.46
It is suggested that the “ceiling of safety” is lower and injury risk is higher in recruits with lower baseline fitness.\textsuperscript{38,47} This is due to the increase in physical fitness requirement, the complexity of new physical tasks, and reduced opportunity for recovery resulting in an increased risk of injury during recruit training.\textsuperscript{7,8,18} In BMT, multiple stressors, such as a caloric deficit, sleep deprivation, continuous physical activity, and mood disorders, in demanding working environments can impair recruits’ working capacity.\textsuperscript{7,18} Upon completion of BMT, soldiers’ physical fitness and military skills need to be sufficient to continue to advanced training and mission preparation while minimizing large fluctuations in load (e.g. a rapid increase).\textsuperscript{7,18} For optimal development during BMT and the following training periods, it could be useful to include a structured combination of endurance and strength training with appropriately planned variation in training intensity and/or training volume.\textsuperscript{7,17} Depending on the activity, different tools may be suitable for determining the total amount of training load for military personnel (i.e., session RPE, heart rate, wellness questionnaire, speed, volume, mood states (POMS)).\textsuperscript{12,48} Such an approach may assist the identification of any potential “ceiling of safety” for BMT.

While awareness of the “maximal training load” that can be tolerated and how each form of training stress influences the maximum load can inform individuals and support staff (e.g. by reducing external load in times where mental stress becomes elevated),\textsuperscript{26} how to determine this “ceiling of safety” for military recruits is a crucial point of debate. While military fitness standards and expected training loads are typically explicitly defined, they are also subject to change due to a changing source population (the youth of today) but also evolving combat readiness demands. Moreover, at what point does the risk of MSIs in recruits exceed an acceptable range? In order to determine the workload “ceiling of safety” for military recruits, contemporary fitness standards and the acceptable range of MSI risk first need to be defined.

**Ensure a minimum training load is maintained**
Considering the training-injury prevention paradox, low monthly training loads result in higher injury risks than consistent moderate training loads.\textsuperscript{30} Moreover, low physical fitness (at entry BMT) is consistently found as a risk factor for MSIs; this factor presumably also holds for drops in physical fitness after training interruptions.\textsuperscript{3,18,49} Periods with lower monthly training load may occur during breaks in military training (during prolonged courses), physical complaints sustained by individuals, or a shifted focus for a particular time such as weapon handling or military tactics.

Awareness is required in providing training protocols for recruits to prepare purposefully to meet baseline standards prior to entry BMT but also to cover weeks including lower monthly training loads during military training.\textsuperscript{50} However, compliance to such protocols to cover breaks in training should also be consciously addressed (e.g. by raising self-responsibility levels in recruits).
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Avoid inconsistent ‘boom-bust’ workload patterns
The advice in sports is to maintain physical capacity where possible so that the athlete can develop the capacity to tolerate the ongoing demands of the sport.11 Ironically while large fluctuations in duty and load (i.e. inconsistent loading patterns, also called ‘boom-bust’ workload patterns) are more the rule than the exception in the military, there is some evidence that a training load-injury relationship also exists in military populations, although the number of studies is limited.51,52,53

Such ‘boom-bust’ workload patterns can occur if training is resumed at the same level of fitness as previous, despite lack of training (e.g. during a break in training or while suffering from an MSI, despite providing training protocols and/or the best efforts from rehabilitation professionals).10 In case of injuries, temporary adjustments such as specific activity restrictions (i.e. week-off loaded marches) can be prescribed, resulting in lower monthly training loads than uninjured counterparts.54 With limited time in BMT and a strict attendance requirement, careful load management is challenging but necessary to avoid ‘boom-bust’ workload patterns. In the eyes of recruits, it may be tempting to resume training at the level of uninjured counterparts, rather than carefully progressing load to the required level corresponding to the phase in BMT.

Carefully planning training load, monitoring load and making adjustments in prescription, while also avoiding inconsistent loading patterns in individuals (e.g. through provision of flexible training times) may provide solutions to optimize training adaptations and reduce injury and attrition risks.7,13,50

Ensure training loads are proportionate to the workload demands of the sport
Intensive training has been associated with high injury incidence.55 Conscious planning of the preceding training loads, as well as a well-advised view to the workload demands (e.g. goals and outcomes of training and/or preparation phase), are important to ensure that changes in training loads are within established safety guidelines.11

The fitness standards of all branches of the military and other special units have differing exercises, standards, and distances in runs and swims.56,57 Also, intensive training such as strategic training and shooting camps are fundamental for training active-duty personnel. Upon entry to BMT, recruits should be prepared to endure such training. Like sports, military commanders require their military unit to be prepared for the most demanding occupational tasks of their specific field (in other words, “train as you fight”), although identifying these evolving demands presents challenges.

It has been suggested that heart rate and session RPE are suitable measures to quantify training load during BMT and military occupational tasks,23,27,58 However, normative reference ranges have yet to be established.27
Monitor the athlete throughout the latent period
The latent period of an MSI is the time between its biological onset (such as inappropriate loading) and the time of first symptoms, which has shown to be up to 28 days in sports. A team of training and medical specialists closely monitor military recruits. Such monitoring provides opportunities for quantifying individual training load, measuring physical and military capabilities, and if applicable, timely registration of MSIs and dropout.

Training load, training outcomes, and MSIs can be combined to investigate causation and inform timely rehabilitation, as well as identify required resources based on empirical evidence. Routine and ongoing monitoring of training load is needed to complete this process. During the training process, stakeholders should collaborate to monitor the athlete before, throughout, and after the latent period, and make appropriate adjustments to training whilst recovering and resuming military training.

PRACTICAL APPLICATIONS
Despite distinctions in job requirements between tactical professionals and athletes, the principles of load management to manage injury risk in athletes can also be applied in military recruits, with the aim of reducing the risk of musculoskeletal injuries and attrition from training. The following load management principles that have successfully been employed in sport are also relevant for basic military training:

1. Establish a moderate chronic workload;
2. Prevent a mismatch between chronic training load prior to military training and training load during the first weeks of military training to minimize the week-to-week changes;
3. Define contemporary fitness standards and the acceptable range of injury risk in order to determine and not exceed the workload ceiling of safety;
4. Provide training protocols for recruits to prepare purposefully to meet baseline standards prior to entering BMT. These minimum standards should be maintained during weeks that include lower monthly training loads during military training in order to ensure a minimum training load is maintained;
5. Carefully plan and monitor training load and make adjustments in prescription to avoid inconsistent ‘boom-bust’ workload patterns;
6. Define the physical demands of military occupational tasks and adjust initial training accordingly (train as you fight) to ensure training loads are proportionate to the workload demands; and
7. Implement ongoing athlete monitoring to identify links between training load and the onset of injuries and make individual adjustments to training accordingly.
CONCLUSION

To conclude, routine scientific monitoring of a combination of external and internal load factors, relevant to the nature of occupational requirements are needed to apply injury prevention strategies in military training. It is proposed that the strategies incorporated within this review could be applied widely in recruit training across military organizations to reduce the incidence of musculoskeletal injuries and associated medical costs whilst enhancing physical performance and organizational effectiveness. Subsequent, individualization and differentiation in training programs is challenging but presumably needed to improve the fitness of all recruits to align with military training. In this paper, we have discussed how load management principles can be applied in military recruit training. Further research is needed to analyze and quantify the relationships between external and internal load and injury incidence in military recruits and whether preventive strategies are able to influence the risk of injury. By focusing on the factors that can be controlled, practitioners can minimize the risk of injury and attrition from training in military recruits.
REFERENCES


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