Integration of strength training into UK Defence Rehabilitation practice: current trends and future challenges

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ABSTRACT

The use of strength and conditioning (S&C) in musculoskeletal rehabilitation has gained wide acceptance among the rehabilitation community. However, there is an absence of evidence demonstrating how to best integrate the principles of S&C into rehabilitation practice. This article discusses four broad themes: (1) an overview of the UK Defence Rehabilitation care pathway, (2) the historical and current approaches to physical training to support operational readiness of the British Armed Forces, (3) the current and future challenges of integrating S&C into Defence Rehabilitation practice and (4) research priorities relating to the use of S&C in Defence Rehabilitation. We detail the importance of strength/power-based physical attributes within our military population. We recommend that consideration be given to the benefits of an alternative education/coaching-based model to be used during the current 3-week residential care pathway, which aims to ensure effective implementation of therapeutic S&C over a longer period of care.

BACKGROUND

The most common reason for medical non-deployable status among military personnel is musculoskeletal (MSK) injury.[1] Soldiers injured during basic training, field exercise and sport may be unable to deploy on operations, while soldiers injured during deployment may not be fit to return to active duty.[2] Subsequently, there is a large economic and operational cost to UK Defence associated with MSK injury. Functional status during rehabilitation is most closely associated with muscle strength.[3] Therefore, maximising the potential for adaptations during strength training is a crucial factor in the progression of any MSK rehabilitation programme. However, there is an absence of evidence demonstrating how to best integrate the principles of strength and conditioning (S&C) into rehabilitation practice.[4] A significant challenge lies in designing optimal rehabilitation programmes that facilitate both neurological and muscular adaptations while concurrently accommodating biological healing, recovery and patient safety.[5] Historically, it has been widely accepted that to elicit significant gains in muscle hypertrophy and strength requires loads equivalent to a minimum of 70% of an individual's one repetition maximum for a given movement.[6] For individuals undergoing MSK rehabilitation, heavy-load resistance training can be contraindicated or they are limited by their symptomatic impairment, including pain and immobility, to attain the recommended heavier loads.[7] Therefore, patients with MSK injuries are often advised to reduce their training load, potentially limiting the desired muscular response to treatment, presenting a challenge to effective service delivery. Despite these known challenges, the use of S&C in MSK rehabilitation has gained wide acceptance among the rehabilitation community. Therefore, the purpose of this clinical commentary is to discuss issues surrounding the challenges of integrating S&C principles into UK Defence Rehabilitation practice.

OVERVIEW OF UK DEFENCE REHABILITATION SERVICE DELIVERY

UK Defence Rehabilitation services are provided through a tiered network within Defence Medical Services. This consists of unit-level primary care rehabilitation facilities (PCRFs), 14 regional rehabilitation units (RRUs) and the Defence Medical Rehabilitation Centre (DMRC) at Stanford Hall (formerly DMRC Headley Court). PCRFs are unit/station-based outpatient departments providing exercise rehabilitation therapy for acute MSK injury. Military personnel with injuries that are unsuitable or do not respond at this level of care are referred to RRUs to allow rapid access to imaging services and residential rehabilitation. This intermediate level of care nests between the PCRF and DMRC. DMRC delivers consultant-led residential rehabilitation for more complex and chronic disorders and injuries, including complex trauma, neurological injury or illness, and chronic or specialist MSK injury/pain. DMRC provides an interdisciplinary approach to rehabilitation with services, including occupational therapy, social work, mental health, prosthesis/orthosis provision, podiatry, speech and language, dietetics and pain management support. Each admission at the RRUs and DMRC is traditionally 3 weeks in duration (readmissions may be provided for more complex or chronic conditions). The overall aim of treatment at each level of rehabilitation care is to restore optimal function and to regain full occupational employability to maintain force readiness. While there is some evidence supporting the efficacy of this 3-week model of residential treatment,[8–10] to our knowledge, there is only one descriptive study specifically investigating the integration of strength training into UK Defence Rehabilitation practice.[11] The primary opportunity for clinical staff at RRUs/DMRC to provide treatment and facilitate favourable medium-term to long-term rehabilitative outcomes is during this 3-week residential admission. Delivery of the exercise component of the multidisciplinary team rehabilitation care pathway and overall responsibility for integrating the principles of S&C into rehabilitation rests with the exercise rehabilitation instructor (ERI) and the physiotherapist. It is acknowledged that there is a particular challenge integrating S&C practice into the residential RRU/DMRC settings. This complex challenge is therefore reflected as a focus for this clinical commentary.

HISTORICAL AND CURRENT APPROACHES TO PHYSICAL TRAINING TO SUPPORT OPERATIONAL READINESS OF THE BRITISH ARMED FORCES

Military training can be physically and mentally demanding. Through necessity, it is vital that soldiers are prepared to function under the uncomfortable conditions they may be exposed to during

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combat. The UK military's historical approach to physical training involved high-volume running, group circuits involving callisthenic-based exercise and marching with load.[12] It was traditionally advocated that high levels of aerobic capacity and muscular endurance were the components of fitness most closely associated with operational readiness.[12 13] However, the training culture of volume over intensity and aerobic conditioning over strength/power-based physical attributes has since been challenged. Many military tasks require an underlying level of muscular strength to perform.[13 14] For example, handling heavy machinery, casualty extraction and performing functional tasks while carrying heavy load (ie, a Bergen).[14] The ability to produce high quantities of force (maximum strength) provides the foundations of a soldier's ability to create explosive movements necessary during close-quarter combat, jumping/landing, multidirectional speed and agility, sprinting and throwing.[12] Therefore, improving or maintaining strength and power is essential to optimise the number of military personnel fit for operational duty. To meet this task, rehabilitation practitioners must individually tailor their programmes to meet the needs of the individual and the occupational standards expected by the British Armed Forces. Furthermore, strength training is consistently shown to be a key component of MSK injury prevention strategies.[15] ERIs and physiotherapists across UK Defence Rehabilitation should become familiar with the updated physical employment standard (PES) and, in particular, the 6-monthly soldier conditioning review (SCR) that measures a soldier's (army-specific) ability to perform various components of fitness (see online supplemental file). Rehabilitation outcomes following traditional MSK injury should therefore be assessed against these new physical standards and gym-based assessment criteria. The updated PES provides a strong rationale for prioritising the development of these strength and power-based physical attributes towards the end stage of rehabilitation and reinforces the importance of why ERIs and physiotherapists must understand the principles of S&C and how to integrate them into MSK rehabilitation. Strategies to improve strength and power during rehabilitation using athletic populations returning to high performance have been described elsewhere.[16]

A summary of commonly used programme variables and monitoring methods is presented in Table 1. These guidelines are well established and widely accepted, but describe recommendations resulting from research using healthy adult populations.[17–19] It is the challenge of incorporating these principles into UK Defence Rehabilitation practice that provides the focus for this commentary.

CURRENT AND FUTURE CHALLENGES OF INTEGRATING THERAPEUTIC S&C INTO UK DEFENCE REHABILITATION PRACTICE

Despite an abundance of information on the implementation of S&C principles with healthy adults, investigations regarding the application of these principles in MSK rehabilitation programmes (or therapeutic S&C) are lacking.[4] Clear clinical reasoning relating to effective progression of therapeutic strength training is essential to achieve positive clinical outcomes.[20] In the absence of evidence to inform decisions regarding the integration of S&C training in rehabilitation, it is recommended that rehabilitating a patient at the site of injury be considered similar to an untrained individual when designing their training programme.[5] While useful as a means of progressing single exercises, this approach is limited in its ability to apply progressions within a multidimensional rehabilitation programme at different stages of a patient's recovery.[20] Consequently, it is difficult to justify the use of formulas and principles for the physiological adaptation to S&C established with healthy adults as a basis for clinical reasoning in the rehabilitation setting.

Table 1 Examples of training variables and monitoring equations based on healthy adults

Variable	Description
Training variables	
Load	The weight prescribed for a given resistance exercise set
Intensity	An estimation of how many repetitions can be completed until failure, at a given load. High-intensity training involves heavy load relative to an individual's 1RM, and thus few repetitions until failure. Low-intensity training involves high repetitions at a lighter load relative to 1RM.
Time under tension	The allocated pace of each phase of the exercise, expressed as three numbers, for example, 3-1-1 (3 s eccentric, 1 s isometric, and 1 s concentric)
Interset recovery	The recovery time allocated between sets
Duration	The time taken to complete a training session
Frequency	The number of training sessions completed per calendar week
Monitoring training	
Volume load (constant load)	Number of sets×number of repetitions×prescribed load (kg) (eg, 3×8×65=1560)
Volume load (progressive load)	(set 1 repetitions×load)+(set 2 repetitions×load)+(set 3 repetitions×load) (eg, (10×55)+(8×65)+(6×75)=1520 kg)
Session intensity Assuming 1RM is 110 kg	Volume load/total repetitions (eg, (10×55)+(8×65)+(6×75)/(set 1 repetitions+set 2 repetitions+set 3 repetitions)) 1520/24=63 (63/110)×5100=57% 1RM
Session density	The relationship between volume load and session duration. The higher the value, the greater the training density (eg, volume load (kg)/time (min) 1560/45 = 34.7 au
Training monotony	The variation in training for the week of training completed. A high value indicates little variation between training sessions (eg, mean volume load for the week (kg)/SD of volume load for the week (kg)) 790/897 = 0.88 au

au, arbitrary unit; 1RM, one repetition maximum.

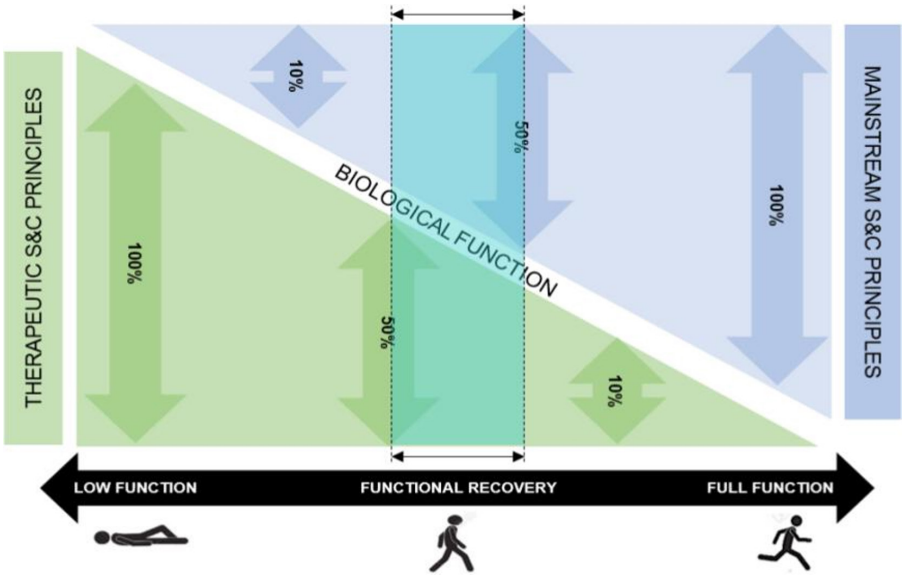

Figure 1 Coppack and Ladlow's theoretical model of the challenges integrating 'mainstream' versus 'therapeutic' strength training principles across the rehabilitation functional continuum. S&C = strength and conditioning.

Figure 1 presents a model that describes the challenges of applying 'mainstream' S&C principles into a complex multimodal rehabilitation programme. In this context, the term mainstream applies to the accepted knowledge and principles derived from research using healthy adults. In this model, the horizontal axis represents a continuum of physical function ranging from low to full functional capacity. The application of mainstream strength training principles (eg, intensity, duration, frequency and exercise order) is maximally exploited when approaching the later stages of functional recovery but is less applicable when physical function is significantly impaired, particularly in the presence of pain. This is represented in the model by the blue triangle and proportional vertical arrows. The green triangle and arrows represent the integration of therapeutic/restorative strength training principles and knowledge employed in the clinical rehabilitation setting. This knowledge is principally applied with patients at the early stage of functional recovery with less reliance at the 'higher functioning' end of the continuum. Therefore, while acknowledging a degree of overlap during functional recovery (Figure 1, shaded rectangle), this model visually shows an inverse relationship between the integration of mainstream versus therapeutic resistance training knowledge, principles and techniques at different stages of the recovery process. However, in the absence of clear guidelines on the integration of therapeutic strength training, decisions on when to increase load and add an external resistance are disproportionately driven by mainstream strength training principles, with little or no rationale for such decision making in a clinical rehabilitation programme. We would argue this approach promotes eminence rather than evidence-based practice. The examination of what constitutes an optimal therapeutic strength training programme is a research priority for UK Defence Rehabilitation.

While the use of S&C within MSK rehabilitation has acceptance across UK Defence Rehabilitation, there remains much debate surrounding how best to integrate accepted principles into the current treatment care pathways. Tables 2 and 3 identify some of the common challenges and proposed solutions from a clinical delivery, education, training and research perspective.

Figure 2 provides a template for exercise programme design considerations and how different components of therapeutic S&C should be prioritised and progressed from point of injury to discharge from rehabilitation care, while taking into consideration operational 'group' and using the updated PES (using the Army PES as an example). During the restorative recovery (figure 2, phase I), the priority is promotion of pain-free movement. Once the therapist is satisfied the patient has completed the early restorative phase, they will perform a thorough needs analysis and identify which occupational group the patient most closely aligns with: group 1: medically discharged (return to civilian life and community reintegration); group 2: sedentary role (eg, desk-based role, low physical demand); group 3: low operational tempo (eg, this will be a unit who has just returned from ops and is just required to meet normal single-service physical testing criteria relevant); group 4: medium operational tempo (eg, units that are about to enter the readiness training cycle for future deployment); group 5: high operational tempo (eg, units that are undertaking training for deployment or units that have ongoing operational commitments, eg, special operations forces). The length of the blue arrows reflects the level of function, training load and physical capacity requirements to meet operational readiness. Operational readiness is determined using the updated PES. Groups 2 and 3 reflect non-ground close combat (GCC) (army non-GCC, not yet complete, to be published in 2021/2022); groups 4 and 5 represent army GCC (see online supplemental file 1). Preparing the injured serviceperson for operational readiness (figure 2, phase II) will require a semistructured, progressive periodised training programme.

One of the most important challenges raised in Table 2 is the lack of objective performance-based outcome measures that can be directly used to inform current and future exercise prescription and programme design across all tiers of UK Defence Rehabilitation. Using examples of measurements currently used within different components of the PES whole career testing continuum (during entry selection, end of basic training and in-service); figure 3 plots these measures against a force–velocity curve. This approach to testing can provide therapists with a simple yet more diagnostic representation of their patient's force-generating capacity, which can be quantified and monitored over time against the updated employment standards expected by the British Armed Forces.

RESEARCH PRIORITIES

UK Defence Rehabilitation must respond to and incorporate an ever-evolving evidence base to meet the needs of its injured personnel while remaining sufficiently flexible to meet the dynamic/changing priorities of the Defence Medical

Table 2 Integrating S&C in UK Defence Rehabilitation: challenges and solutions related to clinical delivery

Commonly cited challenges	Proposed solutions
Clinical delivery	
1. Within the MDT, how do we establish role leadership for the design and implementation of the patient's S&C programme?	The existence of role overlap is inevitable within the UK Defence Rehabilitation care setting, and we believe this is to the benefit of the patient. However, while overlap between disciplines working towards a shared treatment goal is to be encouraged, duplication or poor training load management is actively discouraged. In fostering an effective MDT, clinical leadership, role clarity and treatment boundaries must be well established. Ensuring there are agreed goals on commencement of treatment and effective communication between team members throughout the patients care pathway is recommended. Standardising the approach taken to assess determinants of S&C-related performance and physical performance tests would provide consistent and unambiguous feedback from all therapists involved in the patient care pathway. While ordinarily the clinical team leader would allocate individual responsibilities to implement such solutions, the very nature of an MDT promotes shared decision making across all team members.
2. The availability of an objective performance based-outcome measure that specifically informs the effect of therapeutic S&C interventions.	The recently updated British Armed Forces PES provide an objective measuring tool that can identify the current physical and functional status of military personnel with MSK injury. The PES are well understood by military rehabilitation practitioners; therefore, referring to a patients current physical status against these physical assessment measures may provide an occupational specific means of monitoring strength gains/improvements across the entire rehabilitation care pathway. For example, progress of the patient could be assessed against their capacity to perform exercise on a force–velocity curve (see figure 3) and their functional performance against PES/SCR (see online supplemental file).
3. When administering a concurrent training programme (with multiple competing treatment aims) in Defence Rehabilitation, how do we optimise physical function while avoiding an interference effect?	Concerns related to the interference effect of concurrent training are primarily a concern at the later stages of rehabilitation (figure 2, phase II). This is when greater consideration of exercise selection, course timetabling/programme design and monitoring are required to meet specific areas for improvement identified via clinical and/or performance-based physical assessments. Understanding the physical requirements of a patient (PES) is therefore vital to ensure strength programmes can be designed to accelerate rehabilitation care. Furthermore, careful scrutiny of group-based exercise classes is vital to ensure the principles of therapeutic S&C are being correctly incorporated or modified to meet the needs of the individual.
4. How do we achieve morphological changes in muscle tissue size and strength while following the traditional 3-week period of residential rehabilitation?	It is becoming increasingly recognised that the patient's preintervention expectations will influence postintervention satisfaction.[21] Typically, to achieve significant morphological changes in muscle tissue requires a 8 to 12 weeks strength training programme, with early increases in muscle strength primarily explained by neurological adaptations.[22] Therefore, it may be unrealistic to expect significant physiological adaptation to strength training within 3 weeks and for patient expectations of recovery to be met. An alternative approach may involve an emphasis on education, coaching and personalised mentorship in order to empower the patient to self-manage rehabilitation using a home-based programme over a longer duration (eg, 3 months). This would provide a realistic timescale to gain a physiological adaptation thereby aligning patient expectations with known timescales for physiological recovery. Some evidence supporting this approach to rehabilitation care is provided by the existing 1-week hip and groin education programme with 3-month follow-up, which is increasingly showing promising physical, functional and occupational outcomes.[23] This approach would also complement the growing popularity and evidence for the use of telemedicine/telehealth among clinical populations to promote health outcomes and quality of life.[24]
5. How can we integrate the principles of S&C in the presence of acute or persistent pain?	Progressive exposure to painful movements without adverse experience is essential to the desensitisation of non-nociceptive or neuropathic MSK pain.[25] The principles of modifying movement patterns, manipulating training variables, and dynamically adjusting training programme load are available to clinicians (see Table 1). Using training load monitoring methods such as session rate of perceived exertion may also prove clinically useful.[26 27] However, conventional training principles were developed using healthy adults (Figure 1). Incorporating the principles of S&C into MSK rehabilitation where pain is the primary limiting factor to progress remains a considerable challenge. This is an area worthy future research effort.

MDT, multidisciplinary team; MSK, musculoskeletal; PES, physical employment standard; S&C, strength and conditioning; SCR, soldier conditioning review.

Services and UK Military. Research priorities relating to the integration of S&C into MSK rehabilitation include optimal loading to aid safe progression that simultaneously accommodates tissue healing and recovery while achieving strength/hypertrophy adaptations. A review of how exercise therapy is currently prescribed and managed across Defence Rehabilitation (particularly during the structured 3-week residential care model delivered at RRUs/DMRC) is warranted. In addition, determination of whether rehabilitation outcomes are optimised using alternative methods of delivery (an education-based model) should also be considered.

SUMMARY

In this clinical commentary, we detail the importance of strength and power-based

Table 3 Integrating S&C in UK Defence Rehabilitation: challenges and solutions related to education, training and research

Commonly cited challenges	Proposed solutions
Education and Training in S&C	
1. How do we provide a consistent and standardised approach to the training and education of therapeutic strength training across Defence Rehabilitation?	This is an important issue as any inconsistency in training, education and assessment of knowledge will inevitably lead to inconsistencies in service delivery. Further training and education opportunity are recommended to facilitate an agreed understanding of S&C principles and how they can be integrated into UK Defence Rehabilitation practice. This could include, for example: 1. Vocational-based educational pathway: in-house service training delivered by experienced S&C practitioners>attend United Kingdom Strength & Conditioning Association (UKSCA) workshops>gain experience shadowing experienced S&C coaches in local professional sports club and/or university sector organisations>Certificate in the Foundations of S&C (UKSCA S&C Trainer)>UKSCA Accreditation. 2. *University-based educational pathway:* Attend modules on S&C/sport and exercise science degree programmes>enrol on a part-time S&C undergraduate (BSc) degree programme>enrol on a part-time postgraduate (MSc) S&C degree programme>enrol on a part-time PhD programme.
Research	
2.How do we ensure research priorities reflect the importance of S&C in the patient care pathway?	The ADMR and the Defence Rehabilitation Research Co-ordination Group assess all potential research projects against a specific priority setting criteria. These are assessed against four broad themes: 1. The research programme is consistent with mission of the department, unit, defence rehabilitation, MOD. 2. The importance of problem to health and readiness of Armed Forces. 3. The potential value of this research to UK Defence Rehabilitation. 4. The feasibility of completing the research programme or project This criteria and funding opportunities should also be applied to any potential therapeutic strength training research studies. In 2014, ADMR performed a UK Defence Rehabilitation Research Priorities Survey. Practitioners from across Defence Rehabilitation were asked to provide their views on those research questions and topics of central interest to their current rehabilitation practice. This engagement exercise led to two large RCTs (the MILO[23] and BeFit Study[28] and a pilot RCT investigating the use of low-load blood flow restriction training.[10 29] These studies provide a good example of practitioner-led priorities driving the Defence Rehabilitation research programme. This survey process is being repeated and updated in 2020. Alongside the creation of an ADMR-led 'S&C in Defence Rehabilitation Research Group' will be a 'Defence Rehabilitation S&C BPWG', which will serve to promote the use of therapeutic S&C across all tiers of UK Defence Rehabilitation.

ADMR, Academic Department of Military Rehabilitation; RCT, randomised controlled trial; S&C, strength and conditioning.

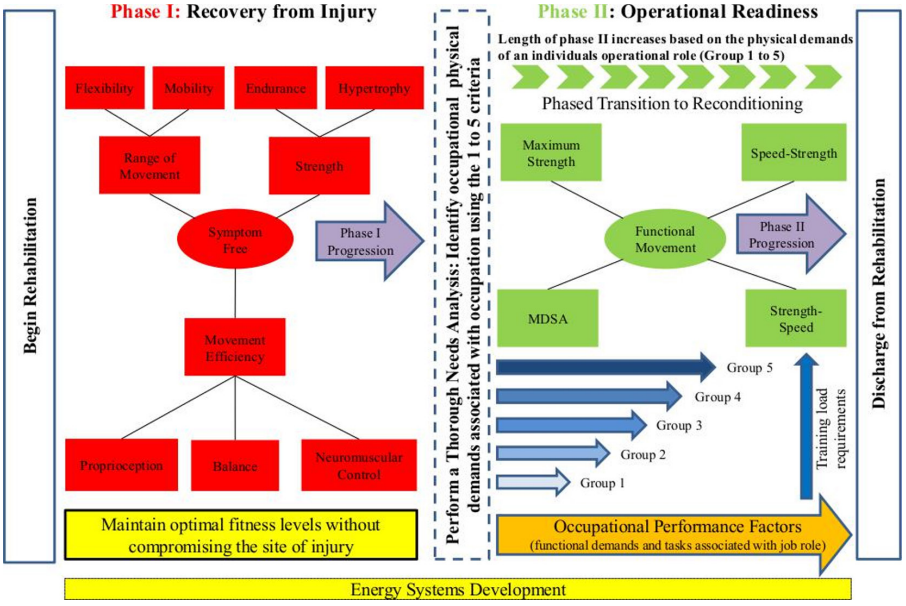

Figure 2 Ladlow and Hayhurst's therapeutic S&C progression model following musculoskeletal injury in UK Defence Rehabilitation. MDSA, multidirectional speed and agility; S&C, strength and conditioning.

physical attributes within our UK military population and reinforce the reasons why medium-term to long-term MSK rehabilitation training programmes could potentially be designed to reflect the updated PES. We provide some areas for consideration that may address these commonly cited challenges. We discuss the potential benefit of developing objective performance-based outcome measures that can be used across all tiers of Defence Rehabilitation that more closely reflect the updated PES/SCR. We would also recommend that consideration be given to the benefits of an alternative education/coaching-based model that aims to ensure effective implementation of therapeutic S&C over a longer period of care (eg, 3 months). Determining optimal loading to aid safe progression of strength/hypertrophy adaptations while simultaneously accommodating tissue healing and recovery is poorly understood across the global MSK rehabilitation community and has now become a research priority for UK Defence Rehabilitation. This article was written immediately prior to the COVID-19 outbreak in the UK. Therefore, it is too early to speculate on what impact the ongoing contingency measures may have on long-term service delivery in Defence Rehabilitation.

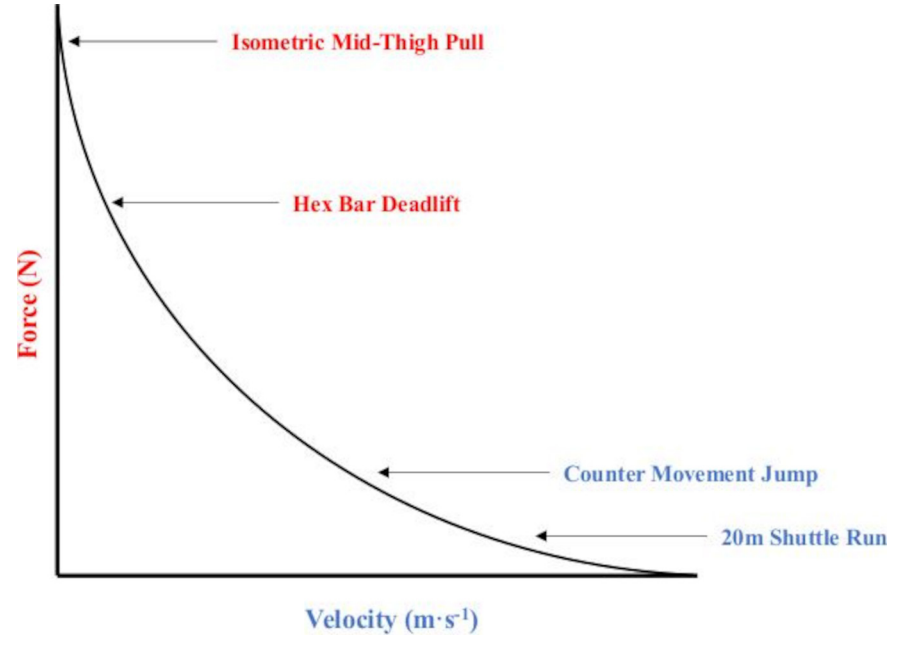

Figure 3 Physical performance measures used within the updated (Army) physical employment standards plotted against the concentric portion of the force–velocity curve.

Acknowledgements The author's thank all staff and patients across UK Defence Rehabilitation for their support and contribution to this article. The authors also thank Vanessa Walters (Academic Department of Military Rehabilitation) for her technical input and comments on the final draft.

Contributors PL and RJC conceived the study idea. PL, DC and RJC wrote the first draft. DH, CS and RPC reviewed and provided detailed comments and revisions on the first draft. All authors participated in further revisions and provided their full approval prior to submission.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

► Additional material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/bmjmilitary-2020-001590).

To cite Ladlow P, Conway D, Hayhurst D, *et al*. *BMJ Mil Health* 2022;**168**:314–319.

Received 5 July 2020
Revised 19 August 2020
Accepted 28 August 2020
Published Online First 21 October 2020

BMJ Mil Health 2022;**168**:314–319.
doi:10.1136/bmjmilitary-2020-001590

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