How 'STRONG' is the British Army?

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BACKGROUND

One of six research themes outlined in the 2021 Strategic Delivery Plan for UK Defence Medical Services (DMS) Research 2021–2026 is '*preventing and treating musculoskeletal injury (MSKI)*'.[1] The research priorities identified include: 'injury prevention and prehabilitation', 'lower-limb injury', 'shortened time to return-to-service' and 'physical comorbidity'. The strategic development plan also identified a need for research investigating 'factors affecting deployment suitability and how they can be assessed and mitigated'.

Three organisations responsible for optimising the physical health and operational readiness of the British Army include the Royal Army Physical Training Corps (RAPTC), Army Health and Performance Research (AHPR) and UK Defence Rehabilitation (with research capability and clinical support driven by the Academic Department of Military Rehabilitation (ADMR)). Among their combined challenges include: (1) The reduction of MSKI, (2) Maximising soldier preparedness to meet the operational demands of combat through the delivery of specific physical training, and (3) Design and management of exercise programmes to optimally accelerate Army personnel becoming fully deployable following MSKI.

All components of fitness are required to successfully perform physically arduous military-specific tasks. However, the ability to produce high forces (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.[2] Therefore, improving or maintaining both maximal strength and the ability to apply force rapidly (ie, rate of force development (RFD)) is essential to optimise the number of military personnel fit for operational duty. Moreover, among the key factors closely associated with the occurrence of MSKI is the application of loads that exceed tissue thresholds.[3] Therefore, in addition to optimising physical readiness,[4] strength training is also considered a vital component of MSKI reduction strategies.[5] A key requirement for physical training staff and rehabilitation practitioners is the need to tailor training/treatment programmes to concurrently meet the functional needs of the individual and occupational standards expected by the British Armed Forces. To meet this requirement, validated assessments of physical performance including force production characteristics are needed.

'Outcome measures' was recently rated the highest research priority by clinical rehabilitation practitioners.[6] Following a recent clinical commentary investigating the integration of strength training into UK Defence Rehabilitation practice,[7] adopting elements of the soldier conditioning review (SCR) and Army role fitness test (RFT) into clinical assessments was recommended. The SCR is a strength and conditioning (S&C) diagnostic tool used to indicate the physical performance characteristics of Army personnel across separate components of fitness. The SCR consists of the broad jump, seated medicine ball throw, hex-bar deadlift, 100 m shuttle run, pull-ups and a 2-km run. RAPTC staff use the outcomes derived from the SCR to adjust and optimise individual and unit S&C programmes accordingly. The isometric mid-thigh pull (IMTP) test is the primary objective marker of lower-limb muscle strength within the RFT recorded at entry (RFT-E) and end of basic training (RFT-BT). ADMR recently demonstrated the acceptability of the IMTP as a method of measuring derivatives of maximal muscle strength during MSKI rehabilitation.[8] However, it was concluded the IMTP values derived from the RFT-E and RFT-BT are too low to inform clinical decision making relating to return-to-duty criteria (ie, 100% of the medically downgraded patients with chronic hip pain could already meet the IMTP standards at RFT-E and 79% could meet RFT-BT), thus questioning the usefulness of existing available standards to inform end-stage rehabilitation guidelines. Additionally, evaluating absolute and relative rapid force production during the IMTP (eg, force at 150 ms, 200 ms and 250 ms), may provide greater insights into the individual's capability and training priorities, especially if expressed as a percentage of their peak force.[9]

Another commonly used neuromuscular performance measure used within S&C practice is the countermovement jump (CMJ).[10] The CMJ is popular because it is simple to administer, requires minimal familiarisation and provides the assessor with a wealth of information regarding ballistic neuromuscular function.[11] For the IMTP and CMJ (figure 1 and table 1), detailed analysis and inspection of force-time characteristics during testing with force

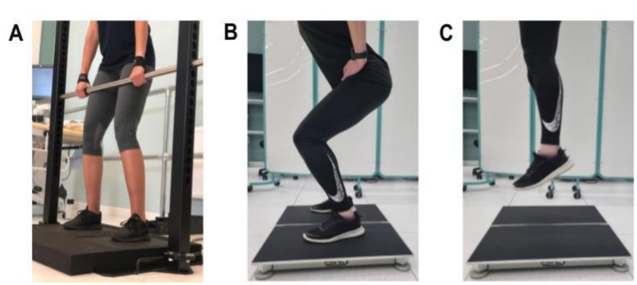

Figure 1 Portable force plate assessments: (A) The isometric mid-thigh pull; (B) Bottom position of the countermovement jump and (C) Top position of the countermovement jump.

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Table 1 Data yielded from the IMTP and CMJ when using portable force plate technology

The isometric mid-thigh pull (IMTP) test	
Currently, the IMTP is used as part of the role fitness test (RFT) at entry and end of basic training. However, due to limitations with existing testing equipment (use of weighing scales), peak force (measured in kg) is the only output derived from the IMTP test used within the Army physical employment standards. When measured using portable force plates (Hawkin Dynamics), the IMTP (figure 1) is a test that can assess multiple derivatives of maximal lower-limb muscle force production capability.	
Current British Army/DMS capability	**Proposed future British Army/DMS capability**
▶ Peak force production (measured in kg)	▶ Peak Force (measured in Newtons (N), and easily converted to kg) ▶ Relative peak force (N/kg) ▶ Force at 150 ms, 200 ms and 250 ms ▶ RFD measured across specific epochs (ie, 0–150 ms, 0–200 ms, 0–250 ms) ▶ Relative RFD measured across specific epochs ▶ Limb asymmetry
The CMJ	
The CMJ can yield valuable insight into an individual's neuromuscular function, ballistic force production capability and stretch-shortening cycle (SSC) capabilities,[11] and greater insight into an individual's capacity to accelerate their body mass. The CMJ has been shown to be a valid and reliable measure of rapid lower-body force production[18] yet it is quick to perform, non-fatiguing and requires minimal familiarisation. Comprehensive insights into neuromuscular function can be gained through detailed analyses of force-time curves throughout specific phases[19] or the entire CMJ,[11] when compared with measuring the output of the jump alone (ie, jump height). Six key CMJ phases can be identified from force-time curves including: weighing, unweighting, braking, propulsion, flight and landing. Combining the IMTP and CMJ will enable the calculation of the participant's DSI. The DSI is the ratio between peak isometric force produced (using the IMTP) versus how much of that force can be produced during a ballistic movement (using the CMJ).[20] This enables the profiling of an individual's 'strength potential' and how much of this potential is being used during high-speed ballistic movements (eg, sprinting/jumping) which are essential attributes when performing physically arduous military-specific tasks.[7]	
Current British Army/DMS capability	**Proposed future British Army/DMS capability**
▶ Jump height	▶ Jump height ▶ Time to take off ▶ (modified) Reactive Strength Index ▶ Propulsive phase duration ▶ Mean and peak propulsive force ▶ Limb asymmetry

CMJ, countermovement jump; DMS, Defence Medical Services; DSI, Dynamic Strength Index; IMTP, isometric mid-thigh pull; RFD, rate of force development.

plate technology are almost instantaneous. When combined with increased availability and affordability, portable force platforms have become one of the most frequently used assessment tools in the field of S&C research, specifically for performance profiling, neuromuscular fatigue monitoring and guiding return from injury.[10] For this reason, the use of this technology is becoming increasingly widespread across military settings. Indeed, the US Department of Defense recently invested heavily in force plate technologies, with all four major branches of the US military now using this technology in their training and operational settings.[12] To date, there have been mixed findings regarding the use of force plate derived CMJ metrics to inform/predict future MSKI risk in US military recruits/trainees.[13–15] This may be due to different force-time variables being used across studies.

MEETING THE CHALLENGE

To maximally exploit the future use of portable force plate technology across the British Army and UK Defence Rehabilitation, key stakeholders agree the first step should be to identify normative reference values of personnel already employed in their primary job role (ie, non-trainees/recruits or medically downgraded (often due to MSKI or mental health)). Access to normative strength data (derived from the SCR and portable force plate technology) could provide important metrics to better understand the functional requirements of Army personnel based on age, sex and job role.[16]

ADMR, the RAPTC and AHPR will collaborate on 'The **STR**ength Pr**O**fili**NG** of Army Personnel' (STRONG) Study. This prospective cohort study will recruit approximately 2000 British Army service members, aged 18–55 years from a range of ground close combat (GCC) and non-GCC roles, and has three primary objectives:

1. Determine sex, age and role-specific performance standards for British Army personnel using data derived from the SCR and portable force plate technology.
2. Produce a scale of reference values for each fitness assessment within SCR and derivatives of muscle strength using data derived from the IMTP and CMJ tests (table 1 and figure 2).
3. Conduct injury surveillance for 2 years following the SCR to determine any

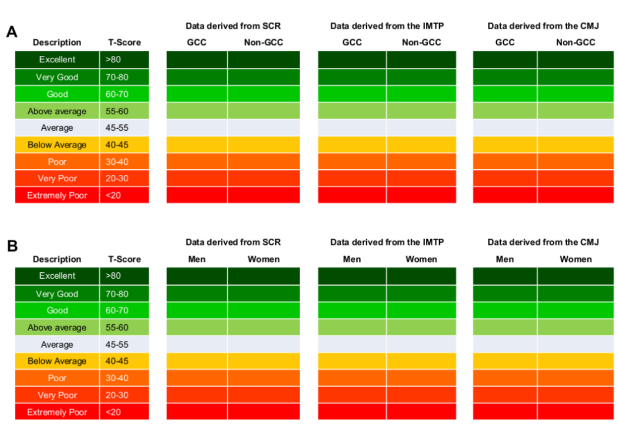

Figure 2 An example visualisation of how data derived from the SCR, IMTP and CMJ will be communicated to UK Defence at the end of the study; based on (A) job role (GCC and non-GCC), and (B) sex (men and women). Inspired by McMahon *et al*.[17] CMJ, countermovement jump; GCC, ground close combat; IMTP, isometric mid-thigh pull; SCR, soldier conditioning review.

potential associations between SCR, IMTP or CMJ values and future injury occurrence.

Currently the only measurements recorded from the SCR are 'pass' or 'fail'. As part of this research programme, maximum relative scores will be collated (ie, time to complete the 2 km run (minutes:seconds), load lifted (kg) or distance thrown (m)) and relationships between SCR values and specific force-time characteristics from the IMTP and CMJ (Hawkin Dynamics, Westbrook, Maine, US) will be determined. With participant consent, research staff will also access medical records to identify any entries relating to a physiotherapy appointment for an MSKI within 2 years following their SCR date. This will enable the research team to determine whether force plate derived IMTP and CMJ variables (table 1), or SCR values are associated with future injury occurrence.

PRESENTATION AND COMMUNICATION OF FINDINGS

Objective benchmarks cannot be determined for any test metric without the existence or creation of cohort-specific normative data sets.[17] A visual representation of how this normative reference data will be communicated can be found in figure 2. Inspired by McMahon *et al*,[17] this traffic light system, with accompanying qualitative description of performance, provides the end user (RAPTC staff and rehabilitation practitioners) with a simple yet more diagnostic representation of the force generating capacity of healthy Army personnel. From an occupational performance perspective, this visual tool may help to identify individuals at future risk of a MSKI, providing training staff with a window of opportunity to mitigate such a risk. Benchmarking neuromuscular performance could also inform the preparedness of a serviceperson's ability to meet the physical demands expected of active/operational duty. From a UK Defence Rehabilitation perspective, this visual tool may facilitate clinical decision making and guide progression throughout the entire rehabilitation care pathway. When used in conjunction with other medical screening tools it could also inform future medical grading (or deployability status).

SUMMARY

The application of S&C research applied to physically demanding occupations is required to ensure that personnel are ready and able to perform in the most effective and efficient way possible. Currently, the British Army and UK Defence Rehabilitation are unable to clearly define normative reference values for data derived from the SCR using healthy/trained service personnel. They are also limited in their capability to evaluate multiple derivatives of muscle strength due to restrictions in existing equipment provision. RAPTC staff and rehabilitation practitioners prescribe and design exercise programmes following the completion of a comprehensive needs analyses. The process of performing a needs analysis helps to identify the training needs of the individual and role-specific requirements expected by the British Army. The inability to clearly define normative reference values (based on age, sex and job role) highlights a substantial knowledge gap in our ability to accurately inform and optimise exercise training strategies across UK Defence. The STRONG Study represents the first combined research effort between the British Army and DMS to meet these specific challenges. With internal collaborations across UK Defence and external collaborations within academia and industry, the STRONG Study will help to address key DMS-identified MSKI research priorities.

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