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Mitigating the risk of musculoskeletal injury: A systematic review of the most effective injury prevention strategies for military personnel

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ABSTRACT

Objectives: To update the current injury prevention strategy evidence base for making recommendations to prevent physical training-related musculoskeletal injury.
Design: We conducted a systematic review to update the evidence base on injury prevention strategies for military personnel.
Methods: Literature was systematically searched and extracted from five databases, and reported according to PRISMA guidelines. Sixty one articles meeting the inclusion criteria and published during the period 2008–2015 were selected for systematic review.
Results: The retrieved articles were broadly categorised into six injury prevention strategies; (1) conditioning, (2) footwear modifications, (3) bracing, (4) physical activity volume, (5) physical fitness, and (6) leadership/supervision/awareness. The majority of retrieved articles (n = 37 (of 61) evaluated or systematically reviewed a conditioning intervention of some nature. However, the most well-supported strategies were related to reducing physical activity volume and improving leadership/supervision/awareness of injuries and injury prevention efforts.
Conclusions: Several injury prevention strategies effectively reduce musculoskeletal injury rates in both sexes, and many show promise for utility with military personnel. However, further evaluation, ideally with prospective randomised trials, is required to establish the most effective injury prevention strategies, and to understand any sex-specific differences in the response to these strategies.

1. Introduction

Musculoskeletal injuries (MSkI) are the primary cause of medical discharge and medical downgrade in the United Kingdom Armed Forces.[1] Given the impact of MSkI on deployability and combat effectiveness, understanding how to most effectively mitigate against this risk is crucial for achieving, maintaining and retaining a healthy, effective and operationally deployable workforce. Physical training (PT) is a primary cause of, and risk factor for, MSkI,[2] yet developing and maintaining physical capability is a critical aspect of military training and employment. Acquiring and maintaining a high level of physical fitness (aerobic endurance, anaerobic endurance, muscle strength and muscle endurance) is necessary for successful performance of military-specific tasks during training and operations. Optimising this cost-benefit trade-off between PT-mediated combat effectiveness and injury risk is critical for achieving and maintaining the required performance standards, and reducing injury rates, of Service personnel. Mitigation strategies for MSkI therefore include, but are not limited to, optimising PT and injury prevention.

Women are at higher risk of MSkI than men throughout military training and employment.[1] Accordingly, female sex is often considered a major risk factor for injury.[3] However, this risk may be reflective of lower aerobic fitness in women than men, rather than a fundamental sex difference in injury risk.[3] Currently, it is not known whether different injury prevention strategies should be adopted for men and women to promote recovery from injury and protect against future injury. During initial military training, rates of MSkI, and particularly rates of debilitating injuries including hip and pelvic stress fractures, are higher in women and Infantry males than men undergoing Standard Entrant military training.[1] If women are to be successfully incorporated into the Combat arms, the projected increased risk of MSkI in this demographic group will require attention. Understanding the most effective strategies for injury prevention will facilitate this mitigation of risk and promote a healthier Force that is effective in combat.

We undertook a systematic review of the literature relating to prevention strategies for PT-related injuries. This review was

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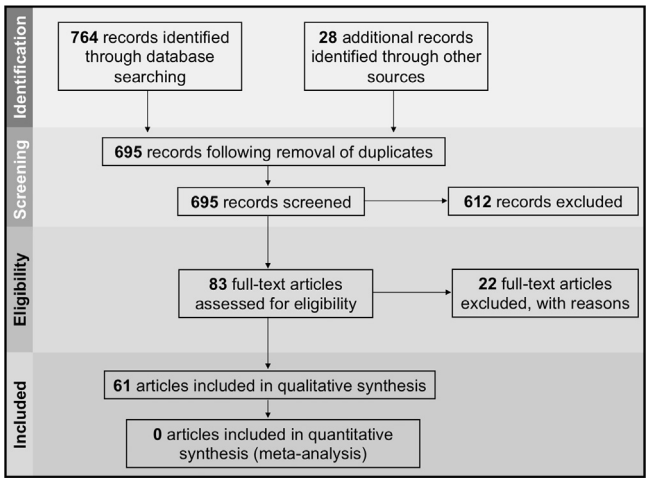

Fig. 1. PRISMA flow chart detailing article identification, screening, eligibility and inclusion (adapted from Moher et al.[72]).

undertaken to update the existing evidence base reported by Bullock and colleagues in 2010.[4] Evaluation of 31 PT-related injury prevention strategies by Bullock et al.[4] resulted in identification of 6 strategies that were graded as having a strong evidence base for the working group to make implementation recommendations for the military. These 6 strategies included; (1) prevent overtraining, (2) perform multiaxial, neuromuscular, proprioceptive and agility training, (3) wear mouthguards during high-risk activities, (4) wear semi-rigid ankle braces for high-risk activities, (5) consume nutrients to restore energy balance within 1 h following high-intensity activity, and (6) wear synthetic-blend socks to prevent blisters. Within all successful injury prevention strategies, 4 components were deemed critical to their success. These critical components ('*essential elements*') included; (1) education of military leaders, (2) leadership support, (3) unit injury surveillance, and (4) adequate resources for injury research and programme evaluation.

Our aims were to: (1) update the current injury prevention strategy evidence base for making recommendations to prevent PT-related MSkI covering the period 2008–2015; (2) prioritise the recommendations for MSkI prevention programmes, strategies and policies, with consideration for the influence of sex, and (3) highlight areas for further research to evaluate interventions likely to reduce PT-related MSkI. The years 2008–2015 were chosen as the date parameters for our literature search to directly follow on from the papers reviewed by Bullock et al.[4]

2. Methods

Our methodological approach closely followed that outlined in the paper by Bullock et al.[4] Literature was searched and extracted from five databases (PUBMED, COCHRANE, ATHENA, Defense Technical Information Centre Scientific and Technical Information Network, Google Scholar), with papers also identified from the reference lists of appropriate articles. Searches included the terms "injury prevention", AND "physical training" OR "physical fitness". A total of 764 articles were identified from the initial search terms with 28 articles added from the reference lists of appropriate articles. Date filters were applied for all searches, with the exception of 'related articles' to Bullock et al.[4] searched on Google Scholar (where a date filter could not be applied). Filters relating to human studies also were applied where the search engine allowed. A flow diagram of article identification, screening, eligibility and inclusion is provided in Fig. 1. Included articles were published between 2008 and 2015, written in English, and included injury as an outcome measure. Articles were excluded if they; (1) were not written in English (n = 22), (2) were a non-research paper, conference abstract, commentary or narrative review (n = 18), (3) did not directly assess injury prevention (n = 346), (4) used a patient, child or elderly participant cohort (n = 58), (5) covered a different or unrelated topic (n = 126), (6) were duplicated (n = 97), or (7) were published prior to 2008 (n = 42; only 'related articles' to Bullock et al.[4] given the inability to apply a date filter to this search). Following full-text review of the remaining 83 articles, a further 22 articles were excluded for not meeting the review inclusion criteria due to not directly assessing PT-related injury prevention (n = 7) or being a narrative review, book chapter, position statement, conference abstract or commentary (n = 15). Thus, in total, 61 articles were selected for systematic review.

All included articles were classified according to their study type; (1) systematic reviews/meta-analyses (n = 18), (2) intervention studies (n = 37), (3) risk factor/cause studies (n = 6), (4) descriptive epidemiology (n = 0), and (5) case series (n = 0). For intervention studies, the median of the pre-post changes in injury occurrence and/or the difference in injury occurrence between intervention and control groups is provided in Table 1 as a representative approximation of intervention effectiveness. However, this method is not equivalent to the rigours of a meta-analysis and thus should not be considered as a pooled effect size.

Systematic reviews/meta-analyses, intervention studies and risk factor/cause studies were graded in relation to the overall effect of the intervention/risk factor on injuries. Each intervention and risk factor/cause study was qualitatively scored (Table 2) using a study quality scoring system adapted from Thacker et al.[5] by Bullock et al.[4] Strategies (from various studies) were graded on the overall evidence for their effectiveness of use in injury prevention. For grading of strategies, a four-colour scale was used (adapted from Bullock et al.[4]) representing strategies; with good to fair evidence to recommend or strongly recommend (green), strategies with fair evidence to recommend but where no clear recommendations could be made due to a lack of clear difference between benefits and harms and/or a benefit to only a small proportion of the population (amber), strategies with good to fair evidence to recommend against (red) or strategies with insufficient evidence to make a recommendation for, or against (grey). Prioritisation of the strategies was based on assessment of the strength of evidence, considering the amount of evidence for/against the given strategy; homogeneity of findings; and quality of evidence according to the scoring matrices. Strategies with sufficient evidence to make recommendations for injury prevention were ranked using a 5-point scale scoring matrix developed by the US Army Center for Health Promotion and Preventive Medicine and the John Hopkins Center for Injury Research and Policy, detailed by Bullock et al.[4] The strength of evidence (scientific quality), magnitude of effect and the practicality of implementation were given a greater weighting in the scoring matrix to represent the importance of these factors. Time to implement and achieve a reduction in injury incidence, sustainability, measurable outcomes and collateral benefit were all considered of secondary importance. Overall prioritisation of strategies with average quality and priority scores are provided in Table 2.

3. Results

The eligible full-text reviewed intervention studies were broadly categorised into 6 types of injury prevention intervention. These intervention categories included; (1) conditioning (n = 26[6–31]), (2) footwear modification (n = 6[32–37]), (3) bracing (n = 2[18,38]), (4) physical activity volume (n = 5[39–43]), (5) physical fitness (n = 3[44–46]) and, (6) leadership/supervision/awareness (n = 3[14,47,48]). Eighteen systematic reviews/meta-analyses

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