Institution:
Bangor University, 10007857

Unit of Assessment:
UoA 24 - Sport and Exercise Sciences, Leisure and Tourism

Title of case study:
Changing diet and supplement guidance in the UK Army to improve health and performance

Period when the underpinning research was undertaken:
2003 – 2017

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
1) Professor Neil Walsh	1) Professor in Sports & Exercise Science	1) August 2000 – October 2019
2) Dr Sam Oliver	2) Reader in Sport & Exercise Science	2) April 2007 – present
3) Dr Matthew Fortes	3) Lecturer 2 – Sports Physiologist	3) April 2010 – May 2015

Period when the claimed impact occurred:
August 2013 – 31 December 2020

Is this case study continued from a case study submitted in 2014? N

1. Summary of the impact

In a series of UK Ministry of Defence (MoD) funded studies, Professor Walsh's team at Bangor University has demonstrated that illness, injury, and underperformance during military training are significantly influenced by deficits in the soldiers' diet. Subsequent field studies with the Army demonstrated the health and performance benefits of additional dietary energy and vitamin D intake. Consequently, the Army changed policy, implementing: 1) an energy-rich training supplement with **all** soldiers that participate in the arduous Infantry Battle School Courses; and 2) an oral vitamin D supplement with **all** recruits that complete initial training, and **all** personnel in the COVID support force.

2. Underpinning research

Bangor research completed between 2003 and 2017 was led by Professor Walsh, Dr Oliver and Dr Fortes. The research was commissioned by Headquarters Army Recruiting and Training Division Occupational Medicine (HQ ARTD) and BAE Systems (Operations) Limited via awards totalling GBP1,485,216 **[3.a – 3.c].** This work has been supported by researchers from the Universities of East Anglia and Manchester since 2013.

In the first study for HQ ARTD, the Bangor team demonstrated that *arduous military training weakened the immune system and increased infection in Army recruits* compared to age-matched controls **[3.a, 3.1]**. In subsequent HQ ARTD-commissioned research, 7% of recruits were shown to suffer at least one clinician-diagnosed infection during initial, Phase One, Army training, with each infection leading to an average of 3 days lost training **[3.c, 3.6]**. This research also showed that the high physical demands of *Army training increased the risk of musculoskeletal injury* resulting in further lost training days and medical attrition, at significant financial cost: overuse injuries alone cost MoD approximately GBP14,000,000 per annum. In subsequent HQ ARTD-commissioned laboratory and field studies completed between 2006 and 2017, *inadequate nutrition was identified as an important and significant contributor to the increased infection and musculoskeletal injury* observed during arduous military training **[3.2]**.

The Bangor-led research programme completed between 2009 and 2010 at the Infantry Battle School (Brecon) exposed that *energy intake did not match the energy requirements of soldiers* completing the arduous Section Commanders' Battle Course **[3.b, 3.2 – 3.4]**. The research also demonstrated the inadequate energy intake impaired immune function (i.e. reduced leukocyte cell-trafficking, lymphocyte, and mucosal immunity), decreased bone formation (i.e. bone-specific alkaline phosphatase), and reduced muscle mass and decreased physical performance (i.e. loss of lifting strength and vertical jump), which also increased the risk of injury **[3.2 – 3.4]**. Moreover, this research established that providing soldiers with an energy-rich training supplement each evening, as *a 'fourth-meal', prevented the detrimental effects on body composition, physical performance, immune and bone health of training in an energy deficit* **[3.2 – 3.4]**. Soldiers who did not receive the supplement lost muscle mass, became dehydrated, had reduced bone formation and immune function, and demonstrated a decrease of 10–20% in physical performance **[3.2 – 3.4]**. Further, those receiving the energy-rich supplement had a lower infection risk as indicated by an approximate increase of 100% in the saliva antimicrobial protein immunoglobulin A (IgA), which forms an important part of the first line of defence to infection **[3.3]**. Critical benefits and impacts were therefore demonstrated at the research stage.

In research completed at Army Training Centre (Pirbright) and Infantry Training Centre (Catterick), between 2013 and 2017, Professor Walsh's team examined the influence of iron and vitamin D status on male and female recruit performance and health during Phase One Army training **[3.c, 3.5 – 3.6]**. The findings of the research indicated that in winter approximately *80% of recruits had vitamin D levels considered inadequate* by the Institute of Medicine for bone and general health **[3.5 – 3.6]**. The research also showed that these recruits had poorer physical performance, poorer immune function, and were more likely to suffer respiratory infections and injury compared to recruits with optimal vitamin D status **[3.c, 3.5 – 3.6]**. Stress *fracture incidence was ~2.5 fold higher in recruits that began training with insufficient vitamin D status* compared to those with proposed optimal vitamin D status.

Consequently, Professor Walsh's team was further commissioned by HQ ARTD to develop and investigate the effectiveness of winter vitamin D supplementation. In a randomised control trial, compared to a placebo, vitamin D supplementation was shown to be effective in *achieving vitamin D sufficiency in almost all recruits* [greater than or equal to 95%] *and reduced infection burden* delivering clear beneficial impacts at the point of the research. Compared to placebo, vitamin D supplementation *reduced the severity of peak infection by 15% and lowered the total days with infection during training by 36%* (6 days) **[3.c]**. As almost all recruits were vitamin D sufficient after supplementation the research also informed the previously unknown correct vitamin D doses for future Army supplementation.

3. References to the research

Research Outputs

3.1 **Walsh, N. P**., Whitham, M., Laing, S. J., Dorrington, M., Walters, R., Dunklin, S., Bland, D. and Bilzon, J. L. (2006) The influence of an arduous military training programme on immune function and upper respiratory tract infection incidence. *Military Medicine*, **171**(8), 703–709. DOI (Peer-reviewed journal article).

3.2 **Fortes, M. B**., Diment, B. C., Greeves, J. P., Casey, A., Izard, R. and **Walsh, N. P**. (2011) Effects of a daily mixed nutritional supplement on physical performance, body composition, and circulating anabolic hormones during 8 weeks of arduous military training. *Applied Physiology, Nutrition and Metabolism*, **36**(6), 967–975. DOI (Peer-reviewed journal article).

3.3 Diment, B. C., **Fortes, M. B**., Greeves, J. P., Casey, A., Costa, R. J., Walters, R. and **Walsh, N. P**. (2012) Effect of daily mixed nutritional supplementation on immune indices in soldiers undertaking an 8-week arduous training programme, *European Journal of Applied Physiology*, **112** (4), 1411–1418. DOI (Peer-reviewed journal article).

3.4 O'Leary, T. J., **Walsh, N. P**., Casey, A., Izard, R. M., Tang, J. C. Y., Fraser, W. D. and Greeves, J. P. (2020) Supplementary energy increases bone formation during arduous military training. *Medicine and Science in Sports and Exercise,* **53**(2), 394,403. DOI (Peer-reviewed journal article).

3.5 Carswell, A. T., **Oliver, S. J**., Wentz, L. M., Kashi, D. S., Roberts, R., Tang, J. C., Izard, R. M., Jackson, S., Allan, D., Rhodes, L. E., Fraser, W. D., Greeves, J. P. and **Walsh, N. P**. (2018) Influence of vitamin D supplementation by sunlight or oral D_3 on exercise performance. 2018. *Medicine and Science in Sports and Exercise*, **50**(12), 2555–2564. DOI (Peer-reviewed journal article).
3.6 Kashi, D., **Oliver, S**., Wentz, L., Roberts, R., Carswell, A., Tang, J., Jackson, S., Izard, R. M., Allan, D., Rhodes, L., Fraser, W., Greeves, J. P. and **Walsh, N**. (2020) Vitamin D and the hepatitis B vaccine response: A prospective cohort study and a randomized, placebo-controlled oral vitamin D_3 and simulated sunlight supplementation trial in healthy young adults. *European Journal of Nutrition*, **61**(1), 475-491. DOI Submitted to REF 2021 (REF identifier UoA24_41).

Grants
3.a **Walsh N.P**. (2003 – 2004) *The influence of a 20-week military training programme on upper respiratory tract infection incidence and immune function in the Parachute Regiment*. HQ ARTD, GBP83,690 (Bangor University: R08207)
3.b **Walsh N.P**. (2009 – 2012) *Effects of energy deficit on physical performance, cognitive function and health during 8 weeks of arduous training*. HQ ARTD, GBP86,136 (Bangor University: R08223)
3.c **Walsh N.P., Fraser W, Fortes M.B., and Oliver S.J.** (2013 – 2017) *Vitamin D, iron status and health of British Army recruits*. BAE Systems Ltd, GBP1,315,390 (Bangor University: R08M02) *This award is the single largest contract ever placed by HQ ARTD.*

4. Details of the impact

The British Army has 117,810 trained soldiers and to maintain the operational workforce trains approximately 12,000 new regular and reserve recruits every year **[5.1]**. All recruits are required to complete initial, Phase One, training that follows a generic syllabus of basic military skills including physical training, weapon handling, map reading, and fieldcraft. Soldiers that become section commanders must also complete the more arduous, Phase Three, Section Commanders' Battle Course. Headquarters Army Recruiting and Training Division Occupational Medicine (HQ ARTD) has responsibility for the training, health, and safety of all British soldiers, and a duty of care, including the provision of adequate and appropriate nutrition.

Research by Professor Walsh's team between 2003 and 2017 established for HQ ARTD that illness, injury, and underperformance during military training are partly explainable by deficits in the recruit's diet. HQ ARTD consequently commissioned Professor Walsh's team to research mitigation of illness, injury, underperformance, and training days lost. All commissioned research programme findings and recommendations were originally provided in confidential reports to HQ ARTD. A consistent feature of this work is that beneficial impacts occurred at the point of the research and nutrition policy changed to benefit the Army and its personnel.

Energy-rich supplement implementation in the British Army
The research programme demonstrated direct benefit to soldiers' health and immune function and also confirmed the practicality of providing an additional 1218 kcal/day energy-rich supplement (45% carbohydrate, 40% fat, and 15% protein) in the evening, as a 'fourth-meal', during arduous training. The impacts demonstrated at the research stage in relation to Army workforce operational performance are critical as confirmed by the Head of Research and Occupational Medicine at HQ ARTD: "*These findings are significant to the MoD because soldiers are regularly deployed on military operations shortly after completing the course*" **[5.2]**. In order to roll-out these benefits, HQ ARTD evaluated the change in feeding policy and identified that the type of supplement provided by caterers was not compliant with Bangor University recommendations to mitigate the risk of injury, ill-health and under-performance. Consequently, this led to an Army policy change in-line with the research team's recommendations whereby the supplement was provided to **all** soldiers undertaking similar arduous training courses at Infantry Battle School (Brecon) with the Head of Research and Occupational Medicine reporting: "*HQ ARTD implemented the recommendations of Bangor University to deliver nutritional supplements to all soldiers undertaking similar courses*" **[5.2]**. The total number of soldiers to benefit from this supplement change each year is between

approximately 720 and 864, which corresponds to approximately 5500 soldiers during this Research Excellence Framework period **[5.3]**.

Vitamin D supplement development and implementation in the British Army

Professor Walsh's team demonstrated to HQ ARTD that vitamin D deficiency is prevalent within Army recruits completing initial training, and is associated with increased illness, injury, and under-performance. Subsequent recommendations to HQ ARTD included a need to develop an intervention that would improve recruits' vitamin D status, especially in winter. These recommendations led to Bangor University being further commissioned by HQ ARTD to develop and investigate the effectiveness of winter vitamin D supplementation on vitamin D status, infection, bone health markers, and physical performance.

As oral vitamin D_3 and simulated sunlight were equally effective at eliminating vitamin D deficiency and achieving vitamin D sufficiency in almost all recruits (equal or greater than 95%), Professor Walsh's team recommended MoD consider oral vitamin D_3 supplementation because it is i) effective regardless of sun-reactive skin type; and ii) represents a more practical field strategy (there is no time burden for an individual or requirement for bulky irradiation cabinets as with the simulated sunlight intervention). Bangor also recommended the oral vitamin D supplementation because recruits improving vitamin D status led to a range of health benefits demonstrated in the effectiveness trials conducted with Army personnel. In particular, vitamin D supplementation reduced the severity of peak infection and days with infection. As almost all recruits were vitamin D sufficient after the supplementation the research informed the correct vitamin D dose for future Army supplementation.

Based on the evidence presented by Bangor University, Army Health recommended to a military judgement panel in March 2020 vitamin D supplementation to support immune health of all service personnel at high risk of exposure to COVID-19. The military judgement panel deemed the evidence 'sufficient' and the recommendations were endorsed. Consequently, the vitamin D supplementation strategy developed during the research was adopted by the Army as part of the enhanced Force Health Protection measures. This included the identical oral vitamin D_3 dose regimen (1,000 IU/day for 4-weeks and then 400 IU/day as a maintenance dose) **[5.4, 5.5]**.

Since April 2020, vitamin D supplements have been issued to support the immune health of **all** Army personnel in initial, Phase One, training (approximately 12,000 per annum) and the COVID support force (approximately 20,000 personnel) **[5.1, 5.4, 5.6]**. The COVID support force has been crucial to aid civil authorities during the COVID-19 crisis performing duties including the delivery of Personal Protective Equipment to hospitals, the building of Nightingale hospitals, and COVID-19 mass testing **[5.7]**.

In summary, Professor Walsh's team demonstrated a need for, and the benefit of, nutritional supplementation, and subsequently, the Army changed nutritional practices implementing two different supplements reaching 100% of the intended target beneficiaries.

5. Sources to corroborate the impact

5.1 **Quarterly service personnel statistics (2020)**. Corroborates Army personnel numbers. https://www.gov.uk/government/publications/quarterly-service-personnel-statistics-2020/quarterly-service-personnel-statistics-1-october-2020

5.2 **Testimonial from HQ ARTD** (Participant in the impact process). Confirms HQ ARTD acted upon Bangor recommendations to implement the energy-rich supplementation in all soldiers undertaking similar Army courses.

5.3 **Testimonial by email from British Army HQ** (Participant in the impact process). Corroborates numbers of soldiers that benefit yearly from the energy-rich supplementation.

5.4 **Testimonial from British Army HQ** (Participant in the impact process). Confirms Bangor research informed the decision to supplement oral vitamin D_3 as part of the enhanced force health protection measures of all Army recruits during initial training, and all Army personnel in the COVID support force.

5.5 **Sky News article (April 2020)**. Corroborates use of vitamin D as part of the enhanced force health protection measures.
https://news.sky.com/story/coronavirus-uk-troops-given-insect-repellent-citriodiol-as-part-of-enhanced-protection-11978318
5.6 **Guardian article (March 2020)**. Corroborates COVID support force numbers.
https://www.theguardian.com/uk-news/2020/mar/18/10000-extra-troops-to-join-british-armys-covid-support-force
5.7 **Voices of the Armed Forces article (November 2020)**. Details the crucial roles performed by the COVID Support Force.
https://medium.com/voices-of-the-armed-forces/covid-support-force-in-numbers-1c67cf8d7280