Immune responses to extreme challenges

Autor(es): Walsh, Neil P.

Publicado por: Imprensa da Universidade de Coimbra

URL persistente: URI:http://hdl.handle.net/10316.2/44069

DOI: DOI:https://doi.org/10.14195/2182-7087_ex2018_6

Accessed: 28-Apr-2019 12:45:37

A navegação consulta e descarregamento dos títulos inseridos nas Bibliotecas Digitais UC Digitalis, UC Pombalina e UC Impactum, pressupõem a aceitação plena e sem reservas dos Termos e Condições de Uso destas Bibliotecas Digitais, disponíveis em https://digitalis.uc.pt/pt-pt/termos.

Conforme exposto nos referidos Termos e Condições de Uso, o descarregamento de títulos de acesso restrito requer uma licença válida de autorização devendo o utilizador aceder ao(s) documento(s) a partir de um endereço de IP da instituição detentora da supramencionada licença.

Ao utilizador é apenas permitido o descarregamento para uso pessoal, pelo que o emprego do(s) título(s) descarregado(s) para outro fim, designadamente comercial, carece de autorização do respetivo autor ou editor da obra.

Na medida em que todas as obras da UC Digitalis se encontram protegidas pelo Código do Direito de Autor e Direitos Conexos e demais legislação aplicável, toda a cópia, parcial ou total, deste documento, nos casos em que é legalmente admitida, deverá conter ou fazer-se acompanhar por este aviso.
ANNALS OF
RESEARCH IN SPORT
AND
PHYSICAL ACTIVITY
IMMUNE RESPONSES TO EXTREME CHALLENGES

Neil P. Walsh

KEY WORDS: Training, Psychological stress, Sleep, Environment, Nutrition

Numerous studies over the last 30 years indicate a decrease in immunity and an increase in upper respiratory infection (URI) symptoms in athletes and soldiers. Experts attribute these observations to the various stressors associated with both athletic training and competition (e.g. heavy exercise, nutritional deficits) and military training and field manoeuvres (e.g. sleep disruption and environmental stress)\(^{(18)}\). Psychological and physical stressors have long been known to influence the sympathetic-adrenal axis and pituitary-adrenal axis since the pioneering work of Walter B Cannon (coined ‘fight or flight’ response) and Hans Selye (coined term ‘stress’) in the 1930s. These common pathways and shared effector limbs for the body’s response to stress in its many forms give rise to increases in circulating catecholamines and glucocorticoid hormones; these hormones are widely acknowledged to have immunomodulatory effects. This presentation will provide new insights about, and recommendations for coping with, the effects of extreme challenges that athletes, soldiers and others encounter on immune health; including, the effects of heavy training stress, life stress, sleep disruption, environmental stress and nutritional deficits.

HEAVY TRAINING STRESS

In athletes under heavy training both innate and acquired immunity are often observed to decrease after heavy exertion, typically 15–25%: prolonged heavy training sessions (> 90 min) and periods of overreaching and maladaptation in particular have been shown to decrease immunity (5, 13). Whether the observed changes in immunity with acute heavy exercise and heavy training are sufficient to increase URI susceptibility remains a point of contention. Recent work indicates that high level athletes are particularly susceptible to URI symptoms during periods of intensified training in the winter\(^{(9)}\). As such, when scheduling

\(^1\) Extremes Research Group, Bangor University, United Kingdom.

https://doi.org/10.14195/2182-7087_ex2018_6
the training programmes of athletes and soldiers, coaches and commanders need to be mindful of the decrease in immunity associated with very prolonged exercise bouts, periods of high training load and when implementing increments in training load.

**LIFE STRESS**

Given the well-known and marked influence of psychological stress on immunity and infection resistance\(^4\), and the shared pathways and effector limbs for the body’s response to various stressors (e.g. exercise, psychological stress) it stands to reason that psychological stress plays a role in the decrease in immunity with prolonged heavy exercise and heavy training\(^15,19\). Unfortunately, exercise immunologists rarely report measures of psychological stress in their studies and so there is little by way of empirical evidence to support this contention. It’s quite conceivable, that psychosocial stress status in high level athletes and soldiers (related to life stress, competition or operations, injury, travel, sleep disruption, jet-lag etc.) accounts at least in part for the influence of acute exercise and heavy training on, immunity and host defence\(^19\). This presentation will make a call to exercise immunologists to account for psychological stress when examining the immune response to exercise; also, for coaches and support staff to monitor psychological wellbeing alongside more traditional physiological measures of training stress. Accordingly, very recent evidence highlights that aspects of mental health such as depression and psychological stress are important risk factors for illness in Olympic athletes\(^6\). Studies are required to demonstrate the utility of interventions to reduce psychological stress in athletes and soldiers experiencing high psychological stress in order to optimise immunity and host defence.

**SLEEP DISRUPTION**

Like the other forms of stress discussed, sleep disturbances influence immunity via activation of the hypothalamic–pituitary–adrenal axis and the sympathetic nervous-system\(^14\). Chronic sleep disturbance and disruption to the normal circadian rhythm are associated with inflammation and desynchronization of rhythmic immune variables. These responses likely contribute to increased risk of infection, cardiovascular disease, and cancer in long-term shift workers. Not only do soldiers experience sleep disruption (e.g. during sustained operations), there is now evidence that athletes experience poor sleep patterns compared with non-athletes. This presentation will highlight what little we know about how sleep disturbance influences the immune responses to exercise. Compared with normal sleep, a disrupted night’s sleep appears to prime the immune system and enhance immune-
surveillance by stimulating total lymphocytes, CD8+ T cells, NK cells, and γδ T cells to leave
the blood and migrate to potential sites of infection during the early recovery period after
exercise\textsuperscript{10}. By contrast, other studies indicate that a night without sleep does not influence
leukocyte trafficking, neutrophil degranulation, or mucosal immunity at rest or after exer-
cise\textsuperscript{14}. Subtle immune changes have been observed after a night without sleep, including a
shift toward a T helper 2 cytokine profile\textsuperscript{11}.

It is uncertain whether these subtle immune modifications with acute sleep loss are
clinically meaningful for the athlete or soldier\textsuperscript{14}. When considering the potential effects
of poor sleep on immunity in athletes and soldiers, it is important to distinguish between
acute and chronic sleep disturbance. Chronic sleep disturbance (12 nights, 50% sleep loss)
increases the plasma inflammation markers C-reactive protein and IL-6\textsuperscript{8}. However, interven-
ing daytime naps can counter this apparent inflammatory response\textsuperscript{17}. Short sleep duration
(<7 h/night for 7 d) decreases the response to hepatitis B vaccination and the likelihood of
clinical protection\textsuperscript{16}. Similarly, a night of wakefulness after hepatitis A vaccination decreases
the specific antibody response 2–4 months later\textsuperscript{12}. People who experience poor quality
sleep and/or regular sleep deprivation also have a 4–5-times greater risk of developing the
common cold\textsuperscript{10}. Continued research efforts should be directed towards monitoring and
improving sleep in athletes and soldiers and understanding the implications for immune
health.

**ENVIRONMENTAL STRESS**

This presentation will cover the controversial beliefs held by many athletes that breath-
ing cold, dry air and getting a ‘chill’ through cooling of the skin cause the ‘common cold’.
Although controversial, some evidence shows that peripheral cooling of the nose and up-
er airways (and even the feet) can increase common cold symptoms, possibly by inhibiting
immune cell trafficking and creating a suitable local environment for viral replication\textsuperscript{7}.
Although not entirely conclusive, evidence indicates that cold exposure often precedes,
and is associated with increased incidence of, URIs including the common cold\textsuperscript{19}. Other
controversies discussed in this presentation include whether exposure to environmental ex-
tremes (e.g. heat acclimation, cryotherapy and hypoxic training) compromises immunity and
increases URI in athletes and soldiers. With the exception of cell-mediated immunity that
tends to be decreased, exercising in environmental extremes does not appear to provide
an additional threat to immunity and host defence. Recent evidence suggests that immune
health may actually be enhanced by regular intermittent exposures to environmental stress
e.g. intermittent hypoxia training\textsuperscript{20}. 
NUTRITIONAL DEFICITS

Nutrient availability can influence immunity directly because macro- and micro-nutrients are involved in a multitude of immune processes (e.g. as a fuel source) but also indirectly via increases in stress hormones during prolonged exercise e.g. when blood glucose falls. Athletes and soldiers either intentionally or non-intentionally experience deficits in energy intake (e.g. extreme weight-loss diets, restricted rations) and macronutrient intake (e.g. restricted carbohydrate). For example, soldiers on a 12-day training exercise in the tropics who received only half of their estimated energy intake in ration packs experienced decreases in both cellular and humoral immunity.(2)

Paradoxically, nutritional strategies currently adopted by endurance athletes, including training with low carbohydrate, may benefit training adaptations and performance at the expense of immunity; for example, carbohydrate restriction may increase the immunosuppressive stress hormone response to exercise(1). As such, the rather modest benefits studies show in terms of training adaptations and performance might, in the long term, be lost if the athlete gets sick more often. Studies are required to investigate whether the nutritional practices adopted by elite athletes impair immunity and increase infection; and, whether purported ‘immune-boosting’ supplements benefit immune health for athletes and soldiers without blunting the desired training adaptations.

This presentation highlights the effects of extreme challenges that athletes, soldiers and others encounter on immune health. Interested readers are directed to recent reviews on the topics covered in this presentation(1,14,19).

REFERENCES

1. Bermon, S. Castell, L. M, Calder, P.C, Bishop, N.C, Blomstrand, E. Mooren, F.C, Kruger, K. Kavazis, A.N, Quindry, J.C, Senchina, D.S, Nieman, D.C, Gleeson, M, Pyne, D.B, Kitic, C.M, Close, G.L, Larson-Meyer, D.E, Marcos, A, Meydani, S.N, Wu, D, Walsh, N.P, and Nagatomi R. (2017), “Consensus Statement Immunonutrition and Exercise”, Exerc Immunol Rev, Vol. 23, pp. 8-50.
2. Booth, C.K, Coad, R.A, Forbes-Ewan CH, Thomson GF, and Niro PJ. (2003), “The physiological and psychological effects of combat ration feeding during a 12-day training exercise in the tropics”, Mil Med, Vol. 168, pp. 63-70.
3. Cohen, S, Doyle, W.J, Alper, C.M, Janicki-Deverts, D, and Turner RB. “Sleep habits and susceptibility to the common cold” (2009), Arch Intern Med, Vol. 169, pp. 62-67.
4. Cohen, S., Tyrrell, D.A., and Smith AP. (1991), “Psychological stress and susceptibility to the common cold” N Engl J Med, Vol. 325, pp. 606-612.
5. Diment, B.C., Fortes, M.B., Edwards, J.P., Hanstock, H.G., Ward, M.D., Dunstall, H.M., Friedmann, P.S., and Walsh NP, (2015), “Exercise intensity and duration effects on in vivo immunity”, Med Sci Sports Exerc Vol. 47, pp. 1390-1398.
6. Drew, M.K., Vlahovich N, Hughes D, Appaneal R, Peterson K, Burke L, Lundy B, Toomey M, Watts D, Lovell G, Praet S, Halson S, Colbey C, Manzanero S, Welvaert M, West N, Pyne DB, and Waddington G. (2017). “A multifactorial evaluation of illness risk factors in athletes preparing for the Summer Olympic Games”, *J Sci Med Sport*, In press.

7. Eccles, R., and Wilkinson JE. (2015), “Exposure to cold and acute upper respiratory tract infection”, *Rhinology* Vol. 53, pp. 99-106.

8. Haack, M., Sanchez, E., and Mullington JM. (2007), “Elevated inflammatory markers in response to prolonged sleep restriction are associated with increased pain experience in healthy volunteers” *Sleep* 30: pp. 1145-1152.

9. Hellard, P., Avalos, M., Guimaraes, F., Toussaint, J.F., and Pyne DB. (2015), “Training-related risk of common illnesses in elite swimmers over a 4-yr period”, *Med Sci Sports Exerc* Vol. 47, pp. 698-707.

10. Ingram, L.A., Simpson, R.J., Malone, E., and Florida-James GD. (2015), “Sleep disruption and its effect on lymphocyte redeployment following an acute bout of exercise”, *Brain Behav Immun* Vol. 47, pp. 100-108.

11. Irwin, M.R. (2015), “Why sleep is important for health: a psychoneuroimmunology perspective” *Annu Rev Psychol*, Vol. 66, pp. 143-172.

12. Lange, T., Dimitrov, S., Bollinger, T., Diekelmann, S., and Born, J. (2011), “Sleep after vaccination boosts immunological memory”, *J Immunol*, Vol. 187, pp. 283-290.

13. Mackinnon, L.T and Hooper S. (1994), “Mucosal (secretory) immune system responses to exercise of varying intensity and during overtraining” *Int J Sports Med* Vol. 15 Suppl 3, pp. 179-183.

14. Peake, J.M., Neubauer, O., Walsh, N.P., and Simpson, R.J., (2017), “Recovery of the immune system after exercise”. *J Appl Physiol* Vol. 122, pp. 1077-1087.

15. Perna, F.M., Schneiderman, N., and LaPerriere, A. (1997), “Psychological stress, exercise and immunity”, *Int J Sports Med* 18 Suppl 1, pp. 78-83.

16. Prather, A.A., Hall, M., Fury, J.M., Ross, D.C., Muldoon, M.F., Cohen, S., and Marsland AL. (2012), “Sleep and antibody response to hepatitis B vaccination” *Sleep* 35 pp. 1063-1069.

17. Shearer, W.T., Reuben, J.M., Mullington, J.M., Price, N.J., Lee, B.N., Smith, E.O., Szuba, M.P., Van Dongen, H.P., and Dinges DF. (2001), “Soluble TNF-alpha receptor 1 and IL-6 plasma levels in humans subjected to the sleep deprivation model of spaceflight”, *J Allergy Clin Immunol*, Vol. 107, pp.165-170.

18. Walsh, N.P., Gleeson, M., Pyne, D.B., Nieman, D.C., Dhabhar, F.S., Shephard R.J., Oliver, S.J., Bermon, S., and Kajeniene A. (2011), “Position statement. Part two: maintaining immune health”, *Exerc Immunol Rev*, Vol. 17. pp. 64-103.

19. Walsh, N.P., and Oliver SJ. (2016), “Exercise, immune function and respiratory infection: an update on the influence of training and environmental stress”, *Immunol Cell Biol*, Vol. 94, pp. 132-139.

20. Wang, J.S., Chen, W.L., and Weng TP. (2011), “Hypoxic exercise training reduces senescent T-lymphocyte subsets in blood”, *Brain Behav Immun* Vol. 25 pp. 270-278.