**Appendix C: Studies examining the influence of sport, exercise, training load and competition on the incidence of illness**

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| **Reference** | **Study design** | **Sport** | **Population (number, level, sex, age)** | **Illness definition / measure** | **Study duration** | **Measurements / monitoring** | **Load monitoring** | | **Load studied** | | | **Multiple risk factors for illness included** | **Analysis** | | **Main findings** |
| **Ext** | **Int** | **Absolute** | **Change in training load** | **Competition** | **Single risk factor model** | **Multiple risk factor model** |
| Svendsen et al 2016 [[1](#_ENREF_1)] | Prospective cohort | Cross country skiers | 39  Elite (medal winners=16)  M=22, F=17  > 18 years | UR infections  GIT infections | 7-8 years | UR and GIT infections  Training monitored using daily logs over 7-8 years  Number of competitions  Number of days at altitude  Number of international flights | Y | Y | Y | Y | Y | Y |  | Y | * UR infections more prevalent in winter/spring than summer * OR for illness increased by competition (2.9) and international travel (4.9) * Training load did not influence odds ratio for illness * Athletes with higher training monotony had 13% lower risk of illness * Medal-winning athletes have lower illness rates than their less successful counterparts |
| Raysmith et al, 2016 [[2](#_ENREF_2)] | Prospective cohort | Track and filed athletes | 33  Elite  > 18 years | Illness episodes | 5 seasons (years) | Illness episodes (medical support team diagnosis)  Training load (weekly)  Illness burden  Performance goals | Y | Y | Y |  | Y | Y |  | Y | * Most illnesses (50%) occurred in the two months prior to competitions * Increased illness burden is associated with a reduction in achieving performance goals |
| Thornton et al 2015 [[3](#_ENREF_3)] | Prospective cohort | Rugby League | 32  Professional rugby league players  Males  26 ± 4.8 years | Illness episodes | 29 weeks | Illness episodes.  Overall well-being and muscle soreness.  Multi-component self-reported questionnaire weekly |  | Y |  | Y | Y |  |  | Y | * Internal training load (TL) measures predict self-reported illness * Weekly TL >2765 AU, monotony >0.78 AU and strain >2282 AU were strong predictors of the incidence of illness * Perceptual ratings of overall wellbeing and muscle soreness are related to the incidence of self-reported illness |
| Veugelers et al 2015 [[4](#_ENREF_4)] | Prospective cohort | Australian football | 45  Elite  Male  > 18 years | Illness episodes (not system specific) | 15 weeks | Illness episodes recorded by team doctor  Training load (daily) (session RPE) (low and high training load) | Y | Y | Y | Y |  |  |  | Y | * The odds of illness was significantly lower in the high training load (RPE field) |
| Svendsen et al 2015 [[5](#_ENREF_5)] | Prospective cohort | Cross country skiers | 44  Elite  M=27, F=17  18-32 years | URS episodes | 2-3 years | URS episodes  Training monitored using daily logs  Effect of participating in a competition (11-day Tour de Ski) | Y | Y | Y |  | Y | Y |  | Y | * 48% of those who took part in Tour de Ski became ill during or after the event vs. 16% of those who did not participate |
| Hellard et al 2015 [[6](#_ENREF_6)] | Prospective cohort | Swimmers | 28  Elite (International=8 and national=20)  M=14, F=14  16-30 years | URS episodes  Other illnesses | 4 years | URS episodes  Other illness (pulmonary, GIT, urogenital)  Training monitored weekly | Y | Y | Y | Y | Y | Y |  | Y | * URS episodes more prevalent in winter * Odds of illness 50-70% higher during intensive training periods than in normal training and competition (10% increase in URS risk with 10% increase in training load) * Illness rates lower among international vs. national level athletes |
| Hausswirth et al 2014 [[7](#_ENREF_7)] | Randomised controlled trial (RCT) | Triathletes | 27 (Control=9, Overload training=18)  Non-elite (regular training)  Male | URS episodes | 3 weeks | URS episodes  Training load  Other: POMS, Performance, Sleep | Y | Y | Y |  |  | Y |  | Y | * Higher incidence of URS episodes in overreached (67%) vs. non-overreached (22%) and control athletes (11%) |
| Martensson et al 2014 [[8](#_ENREF_8)] | Retrospective cohort | Endurance athletes (cross country skiers, biathletes, distance runners) | 11  Elite endurance athletes  M=8, F=3  17-24 years | Illness days (exercise constrained) | 3-16 years | Illness (“sick”) days (exercise constrained)  Training logs (hours) over years (varied between 3-16 years) | Y |  | Y |  |  |  |  | Y | * Training volume (hours per year) negatively correlated to number of days training missed due to illness |
| Gleeson et al 2013 [[9](#_ENREF_9)] | Cross-sectional study | Endurance athletes (running, cycling, swimming, triathlon, team games, racquet sports) | 75  Recreational student athletes  M=44, F=31  18-35 years | URS episodes (questionnaire) | 4 months | URS episodes (weekly)  Training load (hours per week) in three groups (high, medium, low)  Blood samples for haematological and immune parameters | Y |  | Y |  |  |  | Y |  | * Incidence of URS 2.5 fold higher in those training 7-10 hours/week or >11 hours/week vs. those training 3-6 hours/week * High training loads were associated with higher IL-2. IL-4 and IL-10 production in response to antigen challenge |
| Rama et al 2013 [[10](#_ENREF_10)] | Case control | Swimmers | 30 (19 elite swimmers,  11 sedentary controls)  M=20, F=10  14-21 years | URS episodes | 7 months | URS episodes (daily)  Training load (volume, intensity) daily  Competitions  Blood samples for haematological and immune parameters | Y | Y | Y | Y |  |  | Y |  | * Highest incidence of URS (67%) during period of highest training load with 0% incidence of URS in sedentary controls at same time |
| Brink et al 2012 [[11](#_ENREF_11)] | Prospective cohort | Soccer players | 94  Elite  Males  15-18 years | Symptoms of illness suggestive of overreaching | 2 seasons | Symptoms of overreaching (n=7) recorded by medical staff  Training load (RESTQ-Sport scores) monthly  Performance (Interval Shuttle Run Test) | Y | Y | Y |  |  |  | Y |  | * Physical training load related to illness (OR=1.12) * Multinomial regression demonstrated that physical stress was related to both injury and illness (range OR: 1.01-2.59) * Psychosocial stress and recovery were related the occurrence of illness (OR: 0.56 -2.27) |
| Gleeson et al 2012 [[12](#_ENREF_12)] | Prospective cohort | Endurance athletes (running, cycling, swimming, triathlon, team games, racquet sports) | 80  Recreational student athletes  M=46, F=34  18-35 years | URS episodes (questionnaire) | 4 months | URS episodes (weekly)  Training load (IPAC weekly)  Blood samples for haematological and immune parameters  Saliva (IgA) | Y |  | Y |  |  | Y |  |  | * Illness-prone athletes (n=24; >3 URS episodes in 4 months) had higher training load than 30 healthy athletes (0 URS in 4 months) * Illness-prone athletes (n=24; >3 URS episodes in 4 months) had higher SIgASR than 30 healthy athletes (0 URS in 4 months) |
| Cunniffe et al 2011 [[13](#_ENREF_13)] | Prospective cohort | Rugby union | 31  Elite  Males  20-34 years | URS episodes (questionnaire) | 11 months | URS episodes (weekly) web-based diary  Training load (RPE based, daily using web-based diary)  Saliva (IgA, cortisol) | Y | Y | Y | Y |  | Y | Y |  | * Peaks in URS incidence in were preceded by periods of increased training load (intensity) |
| Moreira et al 2011 [[14](#_ENREF_14)] | Prospective cohort | Basketball | 15  Sub-elite  Males  18-21 years | URS episodes (WURSS-21 questionnaire) | 4 weeks | URS episodes (WURSS) weekly  Training load daily (DALDA, session-RPE)  Saliva (IgA, cortisol) | Y | Y | Y | Y |  | Y | Y |  | * Highest incidence of URS during weeks with highest training load |
| Matthews et al, 2010 [[15](#_ENREF_15)] | Prospective cohort | Runners | 35 (12 highly trained runners, 23 students)  M=17, F=18  > 18 years | Symptoms of illness | 3 months | Illness episodes (AIS self reported daily illness log)  Training load (duration and intensity) daily | Y | Y | Y |  |  |  | Y |  | * Frequency of illness episodes was similar in runners and controls * Illness duration and load was higher in runners * Runners who were prone to illness had marginally higher training loads |
| Main et al, 2010 [[16](#_ENREF_16)] | Prospective cohort | Triathletes | 30 (well trained, M=20; 27.1+9.1 years; F=10; 27.4+6.6 years) | URS episodes | 45 weeks | Illness episodes (10 point symptom and sign (SAS) checklist weekly; injuries weekly)  Training load (weekly session number, duration, intensity, perceived effort)  Psychological (stress, mood, training stress, burnout) | Y | Y | Y |  |  | Y |  | Y | * UR illness episodes were significantly associated with increases in training factors (p<0.05) * UR illness episodes were significantly associated with psychological stressors (p<0.001) * Common symptoms of overtraining were significantly affected by increased training and psychological stressors (p<0.001) |
| Spence et al 2007 [[17](#_ENREF_17)] | Prospective cohort | Endurance athletes (triathletes and cyclists) and sedentary controls | 83 (32 elite athletes, 31 recreationally active,  20 sedentary controls)  Male and female  18-34 years | URS episodes (WURSS-44 questionnaire) | 5 months | URS episodes (WURSS) daily  Training load daily (distance, duration, intensity)  Nasopharyngeal throat swabs  Saliva (IgA, cortisol)  Blood (serology) | Y | Y | Y |  |  | Y | Y |  | * Incidence Ratio for URS episodes (elite athletes=4.5, recreationally active=1, sedentary controls=1.9) |
| Ekblom et al 2006 [[18](#_ENREF_18)] | Retrospective cohort | Runners (marathon) | 1694 recreational runners  M=1354, F=340  18-65 years | URS episodes (questionnaire) | 3 weeks | URS episodes (retrospectively 3 weeks before, and prospectively 3 weeks after a 42.2-km race)  Training volume (km/week) (retrospective 6 months before the race) questionnaire | Y |  | Y |  | Y | Y | Y | Y | * Incidence of URS episodes similar pre-race (17%) and post-race (19%) * Incidence of URS episodes higher post-race in those who had pre-race URS episodes (33%) vs. those who did not have pre-race URS episodes (16%) * Pre-race training volume was not related to pre- or post-race URS episodes * Younger age was a risk factor for pre-race URS episodes |
| Novas et al 2002 [[19](#_ENREF_19)] | Prospective cohort | Wide range of physical activities in high school or university students | 31  Wide range of physical activity (elite tennis to non-athletic students)  Females  14-21 years | URS episodes (questionnaire) | 3 months | URS questionnaire (daily)  3-day physical activity record (3 blocks of weekdays and 1 weekend day) (total daily energy expenditure)(quartiles)  Daily tennis training diary (tennis players sub-group)(session-RPE) | Y | Y (sub-group) | Y |  |  | Y |  |  | * URS symptom index higher in low training load quartile but highest in the highest training load quartile |
| Fahlman & Engels 2005 [[20](#_ENREF_20)] | Prospective cohort study | American football | 100 (75 college football players, 25 controls)  Males  18-25 years | URS episodes (questionnaire) | 12 months | URS questionnaire (weekly)  Training (physical activity questionnaires) (8 times in the 12 month period)  Training and Competition periods (defined)  Saliva (IgA) | Y |  | Y |  | Y | Y | Y |  | * Incidence of URS episodes higher during training/competition periods vs. off-season * Incidence of URS episodes associated with lower SIgASR |
| Fricker et al 2005 [[21](#_ENREF_21)] | Prospective cohort | Runners (800m to marathon) | 20  Elite (national and international level)  Male  24+3 years (mean+SD) | URS episodes (questionnaire) | 4 months | URS questionnaire (daily)  Training load (weekly mileage and intensity)  Performance testing (start and end) | Y | Y | Y |  |  | Y | Y |  | * Incidence of URS episodes was not associated with weekly training load |
| Novas et al 2003 [[22](#_ENREF_22)] | Prospective cohort | Tennis | 17  Elite  Females  14-21 years | URS episodes (questionnaire) | 3 months | URS questionnaire (daily)  Training load (daily) (session-RPE)  Competitions (matches per week)  Saliva (IgA) | Y | Y | Y | Y | Y | Y | Y |  | * More URS episodes associated with higher training volume * More URS episodes associated with increased matches per week * More URS episodes associated with higher competition level |
| Anderson et al 2003 [[23](#_ENREF_23)] | Prospective cohort | Basketball | 12 (  College level Females  18-22 years | Illness episodes | 20 weeks | Illness episodes (after each training session)  Training load (session RPE, session duration), monotony, training strain | Y | Y | Y | Y | Y |  | Y |  | * No correlation between total weekly training load and illness rates) |
| Peters et al 1993 [[24](#_ENREF_24)] | Randomised controlled trial (RCT) | Runners (ultra-marathon) | 157  Recreational 84 runners (n=84, M=82, F=2:) Controls (n=73)  > 18 years | URS episodes (questionnaire) | 2 weeks | URS questionnaire (2 weeks post race in the Vitamin C supplemented group and a Control group)  Pre-race training history (training status: ratio of training distance to training speed) | Y |  | Y |  | Y | Y | Y |  | * Incidence of URS episodes was higher in runners (68%) vs. controls (45%) * Incidence of URS episodes was higher in runners with higher training status (increased load) |
| Heath et al 1991 [[25](#_ENREF_25)] | Prospective cohort | Runners | 530  Recreational runners  M=447, F=83  13-75 years | URS episodes (questionnaire) | 1 year | URS questionnaire (daily)  Training log (monthly) (mileage, racing)  Multiple other risk factors | Y |  | Y | Y |  | Y |  | Y | * Increased mileage (training load) was an independent risk factor for URS episodes * Other independent risk factors for URS episodes were living alone, increased BMI, and male gender |
| Nieman et al 1990 [[26](#_ENREF_26)] | Cross sectional | Runners (marathon) | 2311  Recreational (M=1992; F=319)  Non finishers (n=295)  > 18 years | URS episodes (questionnaire) | 2 months | URS questionnaire (once)  URS episodes 2 month pre-race, and 7 day post race)  Training history in 2 months before race  Energy, stress levels, sleep (questionnaire) | Y | Y | Y |  | Y | Y |  | Y | * Pre-race URS risk was higher in runners training >97 km/week vs. 32 km/week (OR=2.0) * Post-race URS risk was higher in finishers vs. non finishers (OR=5.9) |
| Peters 1990 [[27](#_ENREF_27)] | Case control | Runners (ultra-marathon) | 108 recreational runners (M=97, F=11)  108 controls  > 18 years | URS episodes (questionnaire) | 2 weeks | URS questionnaire (twice) – 7 days before and 2 weeks after a race  Training history (distance / week) in preparation for the race | Y |  | Y |  |  | Y | Y |  | * The incidence of URS episodes was twice as high in runners (29%) vs. controls (13%) * Less trained runners had a higher incidence of URS episodes |
| Nieman et al 1989 [[28](#_ENREF_28)] | Cross sectional | Runners (5km, 10km, 21km) | 273  Recreational runners  M=193, F=90)  > 18 years | URS episodes (questionnaire) | 2 months | URS questionnaire (once)  URS episodes 2 months pre-race and 7 days post 5-, 10- and 21-km races  Training history in the 2 months before races | Y | Y | Y |  | Y | Y | Y |  | * URS incidence was lower in runners training 42 vs. 12 km/week * Race participation (5km, 10km and 21km) was not associated with increased URS episodes |
| Linde et al 1987 [[29](#_ENREF_29)] | Prospective cohort | Orienteering | 44  Elite  44  controls  19-34 years | URS episodes (questionnaire) | 12 months | URS questionnaire daily | Y |  | Y |  |  |  | Y |  | * Incidence of URS episodes was higher in orienteers (2.5) vs. controls (1.7) |
| Peters et al 1983 [[30](#_ENREF_30)] | Case control | Runners (marathon) | 150  Recreational runners (M=145, F=5)  124 sedentary controls  18-65 years | URS episodes (questionnaire) | 2 weeks | URS questionnaire (twice)  URS episodes 2 months pre-race and 7 days post 56 km race  Training history (distance / week) in preparation for the race | Y |  | Y |  | Y |  | Y |  | * URS episodes were more common in runners training > 65km/week (40%) vs. those training < 65km/week (20%) * The incidence of URS episodes after the race was higher in runners (33%) vs. sedentary controls (15%) |

M=Males

F=Females

UR = Upper Respiratory

URS = Upper Respiratory Symptom

URTI = Upper Respiratory Track Infection

GIT = Gastrointestinal

IgA = Immunoglobulin A

SIgA = Salivary IgA concentration

SIgASR = Saliva secretory immunoglobulin A secretion rate

RPE = Rating of Perceived Exertion

WURSS – Wisconsin Upper Respiratory Symptom Score

OR – Odds Ratio

TL = Training Load

AU = Arbitrary Units

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