Mental, physical and social health benefits of immersive nature-experience for children and adolescents: a systematic review and quality assessment of the evidence

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Highlights

- 84 publications were identified
- 60% studies indicated benefits for mental, physical or social outcomes
- Benefits for psychosocial, e.g. self-esteem, and cognitive indicators predominant
- Small sample sizes, intervention heterogeneity and risk of bias were observed
- Quality of evidence was considered low across types of outcomes
- Suggestions for methodological improvements are made

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Abstract

In this systematic review, we summarised and evaluated the evidence for benefits of immersive nature-experience on children and adolescents' mental, physical and social health. An electronic search was performed for English language articles published between January 2004 and May 2017. Data were extracted from 84 publications that met the inclusion criteria. Study quality was assessed for a subset of the studies, i.e. controlled between- and within-subjects studies, using a systematic assessment scheme, and the quality of the evidence was reviewed at an outcome level. Across heterogeneous types of immersive nature-experience, there was conditional support for benefits on self-esteem, self-efficacy, resilience and academic and cognitive performance. Correlational research evidenced higher levels of physical activity in natural environments than comparison conditions. Benefits for outcomes such as self-concept, problem solving, and mood were more inconclusive. In addition, social skill-oriented and behavioural indicators were improved, although the categories comprised different outcomes. Risk of bias, insufficient sampling methods and unsuited comparison groups were common study limitations.

Keywords: friluftsliv (outdoor life), green exercise, health promotion, social ecology/human ecology, therapy

Introduction

Mental and physical non-communicable diseases, such as major depression, migraine, and diabetes, were the main causes of years lived with disability, i.e. prevalence of the disorder in conjunction with short or long term loss of health, on a global scale in 2013 (Vos et al., 2015). As such, prevention science and health promotion, which is the structures to support and processes of enabling people to exert control over the determinants of health and thereby improve health, is critical. Approximately 13% of children and adolescents world-wide are estimated to suffer from mental disorders, including anxiety, depression, attention deficit hyperactivity, and disruptive disorders (Polanczyk et al., 2015), and there are indications that the rates of depressive disorders have increased over the past decade amongst adolescents (Mojtabai et al., 2016). Similarly, there is a rise in the prevalence of obesity amongst children and adolescents (Ng et al., 2014). As childhood mental, physical and social well-being and lifestyle have been associated with later-life behaviours, function and well-being (Herman et al., 2009; Shonkoff et al., 2009; Taylor, 2010; Telama, 2009), health promotion and prevention targeting children has never been more pertinent.

Nature as an upstream health-promoting intervention

Nature has been considered an affordable, upstream health promotion intervention (Maller et al., 2006), and childhood exposure to nature has been associated with later-life mental health (Dibben et al., 2017; Engemann et al., 2019). This systematic review considered how immersion in natural environments influenced children's and adolescents' mental, physical and social health. While there is a wealth of predominantly correlational literature exploring nature contact and benefits for health (Bowler et al., 2010; Bratman et al., 2012; Hartig et al., 2014; Twohig-Bennett and Jones, 2018), the evidence is both diverse and dispersed, and results may not be directly transferable to children. Kuo (2015) identified 21 pathways in which nature may have

health promotion benefits. Many of these pathways, e.g. presence of chemical and biological agents that influence immune function, may affect adults and children alike. However, natural sights and sounds, for example, may have different connotations and present alternative affordances (Veitch et al., 2007; Yarwood and Tyrrell, 2012) that can be speculated to lead to varying social and physical behaviours and physiological and psychological states for adults, adolescents, and children, respectively. From a neurodevelopmental perspective, the ways in which children and adolescents respond to and process external stimuli may vary from adults because the brain is not fully developed (Lenroot and Giedd, 2006). For example, there is evidence to show that children respond more strongly to noise stimuli and report a higher degree of noise disturbance than adults (Klatte et al., 2010). To investigate whether there is empirical support that nature benefits children, we conducted a comprehensive systematic review of the evidence.

Unfolding the existing knowledge base

We argue that existing reviews concerning children, nature and health have tended to lump together diverse types of interventions – everything from accessibility to nature over passive exposure to natural environments and elements to engagement with natural environments (Faber Taylor and Kuo, 2006) – or focused narrowly on specific types of health outcomes (Tillmann et al., 2018). While other reviews have been highly informative, they have been narrative in their review approach (McCurdy et al., 2010; Muñoz, 2009) and thereby perhaps not exhaustive or without systematic assessments of risk of bias or the quality of the evidence (Faber Taylor and Kuo, 2006; Holland et al., 2018; McCurdy et al., 2010; Muñoz, 2009). To our knowledge, Tillmann et al. (2018) were the first to provide a comprehensive child-focused systematic review and quality assessment. In the review, the authors distinguished between various forms of contact with nature and used this to narratively investigate potential differences in mental health outcomes. Our review adds to and differs from this highly useful and enlightening review in a number of ways. Firstly, we

focus on a particular type of immersive nature-experience, namely the Scandinavian tradition and practice of so-called *friluftsliv*, which includes concepts of, e.g. ‘outdoor life’, ‘outdoor recreation and education’ or ‘adventure recreation and education’, but with an emphasis on the experience of closeness to nature during the activity (Bentsen et al., 2009a; Gelter, 2000). Secondly, we defined health according to the World Health Organization’s holistic and positive definition of health, and identified studies were divided into analytically distinct categories of mental, physical and social health. Inspired by Nutbeam (1998), we considered health, not only as a fixed or steady state, but also as a process influenced by intermediate health outcomes, e.g. lifestyle choices and actions, and health promotion outcomes, e.g. improved health literacy, for instance physical literacy, i.e. a person’s capacities and attitude for engagement in physical activities (Edwards et al., 2018). Strengths of this approach lie in a more exclusive focus on interventions that are more comparable in terms of content and activation of pathways to improved health (Kuo, 2015) and a holistic understanding of health. While we maintain an analytical distinction between mental, physical, and social health outcomes for communicative purposes, these are highly interdependent and developments in one outcome is likely to influence others. Finally, we conducted a systematic assessment of risk of bias in the individual studies and an evaluation of the quality of the evidence on an outcome level. Evaluations of the quality of the evidence at an outcome level are a necessary step towards recommendations for practice in health promotion and prevention science.

Two main research questions frame this systematic review:

- 1) How does immersive nature-experience influence mental, physical and social health outcomes in children and adolescents?
- 2) What is the quality of the evidence at an outcome level?

Methods

The systematic review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher et al., 2009) (for PRISMA checklist, please see supplementary materials A). The present review includes a subsample of studies from a systematic review with a wider scope (results from this larger systematic review are reported elsewhere, see for example (Mygind et al., 2019)). The aim of the larger systematic review was to synthesise the effects and associations of immersive nature-experience on mental, social and physical health promotion outcomes across populations of all ages. Thus, the objective of the larger review was to provide a broad overview, and to gauge the uses and effects of immersive nature-experience in recreational, educational and health sectors. As such, the present review supplements the wider review through a targeted focus on immersive nature-experience that are relevant for children and adolescents, and rigorous study and outcome level quality assessments.

We did not consider it meaningful or possible to evaluate the participants' acute and individual experience of closeness to nature in the identified studies. Therefore, we operationalised conditions under which the nature-experience should take place for the nature-experience to be considered immersive. Inspired by (Bentsen et al., 2009a), immersive nature-experience was operationalised as non-competitive activities, both sedentary and active, occurring in natural environments removed from everyday environments. This, for example, did not include competitive sports in natural environments or transport to and from work or school through natural environments. All motorised activities in natural environments were excluded. The review protocol of the larger systematic review can be accessed on the PROSPERO register of systematic reviews (id: CRD42017057988).

In the present review, we addressed the body of evidence concerning children and adolescents and assessed the quality of the evidence at an outcome level, inspired by the Grading of

Recommendations Assessment, Development and Evaluation (GRADE) framework (Guyatt et al., 2008).

Eligibility criteria

Publications were included in this review if they presented one or more empirical original studies; were communicated in Danish, English, Norwegian or Swedish language; and had been published between January 2004 and May 2017. The latter of these criteria was chosen to extend the knowledge from previous reviews on immersion in nature and health, which included studies published before 2004 (Sandell, 2004; Schantz and Silvander, 2004). We did not include conference abstracts.

Studies were included if they used quantitative approaches to investigate associations between or effects of immersive nature-experiences, according to the above described operationalisation, on children and adolescents' mental, physical or social health. Only child and adolescent populations (i.e. up to 18 years of age) were included. If papers covered populations under and over the age of 18 and the reporting allowed for a separation of results for populations under 18, papers were included. In practice, no such papers were identified.

Information sources

We conducted a literature search in the electronic databases Dissertation Abstracts, ERIC, PsycINFO, Scopus, SPORTDiscus, and Web of Science. The search was finalised by the beginning of May 2017. A generic search string was adapted to the individual electronic databases (see supplementary materials B). We attained additional literature through snowballing, i.e. manual reference list checks (Greenhalgh and Peacock, 2005), of all identified relevant publications.

Study selection

All identified literature was screened by pairs of individual reviewers (LM, EK, RH, and EM) by reading through titles and abstracts. Subsequently, full-text eligibility was determined by two independent reviewers. Disagreements were settled through discussion between the two reviewers. If an agreement could not be made, a third reviewer (PB or LM) made the final decision.

We identified 84 individual studies that fulfilled all eligibility criteria. These studies were, as mentioned above, a subsample of a larger systematic review that followed the screening procedures described (see Figure 1): two levels of screening were used on 7,022 citations, excluding 6,296 publications that were outside the scope of the larger systematic review, and therefore also this systematic review. Two reviewers assessed 726 publications in their full length. Including publications identified through snowballing ($n = 135$), the process resulted in 461 publications that were included in the larger systematic review. These publications related to immersion in nature and mental, social and physical health. Applying the described inclusion criteria of this review led to the exclusion of another 377 publications, resulting in the 84 original publications (comprising 90 individual studies) that met all inclusion criteria. Main reasons for excluding studies at this stage were that studies were based on qualitative approaches or included adult populations. Some studies included participants that were both over or under the age of 18 and were excluded from this review (e.g. Kalisch et al., 2011; Mirkin, 2013; Sibthorp et al., 2008).

Data items and extraction process

Data were obtained from the literature by a single investigator (LM and EK) using the same generic data extraction form. Data extracted from the literature included: study information (i.e. publication year, authors, and country in which the study was performed), study sample (sample size, sex, participant characteristics, e.g. information relating to any diagnoses, sociodemographic,

or particular group affiliation, and age), study design (inspired by Ryan et al. (2013)), activity, duration of exposure, characteristics of natural and control conditions, outcome measures, and reported results.

Figure 1. Flow chart.

Risk of bias in individual studies

We conducted risk of bias assessment of all within- and between-subjects studies that included a form of control group or condition. Risk of bias in between-subjects studies was evaluated with inspiration from the Cochrane Collaboration's tool for randomised trials (Higgins et al., 2011). Items in the tool are categorised under six bias domains: 1) selection (random sequence generation and allocation concealment), 2) performance (blinding of participants and personnel), 3) detection (blinding of outcome assessment), 4) attrition (incomplete outcome data), 5) reporting (selective reporting), and 6) other bias (e.g. analytical or sampling bias). As has been argued elsewhere (Brussoni et al., 2015), the characteristics of nature-based interventions and programmes do not allow for allocation concealment or full blinding of participants and personnel to the received intervention. However, blinding of participants and personnel to the specific study aims and research questions was assessed instead of these items. For non-randomised between-subjects studies (i.e. controlled pre-post studies), we evaluated attempts to match intervention and control groups and level of reporting with regard to demographic comparability and similarity of baseline scores on outcome variables of the groups.

For within-subjects studies, risk of bias was assessed using the items identified by Ding et al. (2015). The items include: 1) appropriate cross-over design, 2) randomised treatment order, 3) carry-over effect, 4) unbiased data, 5) allocation concealment, 6) blinding, 7) incomplete outcome data, 8) selective outcome reporting, and 9) other bias.

For both between- and within-subjects studies, risk of bias for the individual items was considered low, unclear or high.

Summary measures and synthesis of results

Given the heterogeneity of outcomes and interventions, we did not consider meta-analyses appropriate. We divided results from within- and between-subjects controlled studies into five categories, in order to provide a narrative synthesis of the results for the individual outcomes: 1) nature immersion was found to be beneficial, 2) nature immersion was found to be beneficial, but not more than control group or condition, 3) results were mixed, that is, different measures for the same outcome used in the individual study provided different results (i.e. beneficial, insignificant or harmful), 4) differences between nature immersion and control were insignificant, and 5) nature immersion was found to have a detrimental impact on the outcome.

Risk of bias across studies

Results from the risk of bias assessments were aggregated across the individual risk of bias items. Only within- and between-subjects studies that included a form of control group or condition were included. Inspired by the GRADE framework (Guyatt et al., 2011, 2008), we assessed not only risk of bias within and across the individual studies, but also the quality of the evidence across studies at an outcome level. Upon identification of outcomes that had been investigated more than once amongst the identified studies, we subjected the body of research to an overall assessment relating to 1) risk of bias, 2) imprecision, 3) inconsistency, and 4) indirectness. Outcomes under the social and physical health domain were rarely explored more than once. Therefore, social health outcomes were grouped under a relational, skills and behavioural category. Under the physical health domain, physiological indicators of stress response were grouped.

According to GRADE, randomised controlled trials (RCTs) start as high quality evidence, and non-randomised studies start as low quality evidence (Guyatt et al., 2011). Given that the shortcomings of RCTs with randomised group allocation are increasingly recognised (Frieden, 2017) and potentials of randomised within-subjects studies to provide reliable estimates under

appropriate conditions (Gottfredson et al., 2015), randomised cross-over within-subjects studies were considered high quality evidence.

The quality of the evidence on an outcome level was rated down if the body of the included studies were judged as having a high risk of bias, imprecision (e.g. low power or large standard deviations), inconsistent findings, or issues relating to indirectness, that is, a lack of coherence between intervention and review question (e.g. if the comparison group or condition did not include ‘treatment-as-usual’-type content or if the used outcome measures and instruments were suboptimal).

Inspired by Brussoni et al. (2015), we did not downgrade the quality of the evidence if the only source of indirectness stemmed from use of caregiver-, teacher-, and self-report measures, although these are likely to introduce a degree of social desirability bias.

Results

Study characteristics

Within the 90 individual studies from 84 publications included in the review, 36 utilised some form of control group (see Table 1 for study characteristics of these controlled studies. Non-controlled studies are described in the results section in relation to controlled studies). Most of the controlled studies stemmed from the Americas ($\approx 50\%$, USA $\approx 45\%$) and Europe ($\approx 30\%$). Of the remaining studies, $\approx 14\%$ were from Oceania and $\approx 8\%$ from Asia. Participants were predominantly between 11 and 18 years ($\approx 80\%$) and only approximately 10% of the identified studies included participants under the age of 11 (3-7 years $\approx 3\%$, 7-11 years $\approx 7\%$). Participants included children and adolescents with behavioural and/or emotional disturbances (e.g. attention deficit hyperactivity disorder (ADHD) or depression), substance abuse issues, juvenile delinquency, socially disadvantaged backgrounds, overweight, as well as typically developing children and adolescents. More than 85% of the studies included both male and female participants, only two studies included only female participants and one only male.

Although varying in precise content and scope, the main type of activity was expedition or base camp adventure experiences inscribed in an educational (e.g. teambuilding, anti-bullying initiatives) or health context, (e.g. psychological and/or behavioural treatment). Other types of interventions included green educational breaks or activities, regular curriculum-based activities in schools, so-called education outside the classroom (Bentsen et al., 2009b), and free play in outdoor kindergartens. Interventions were generally compared to treatment as usual or standard care, but in some cases an alternative non-nature intervention was used as comparison, e.g. a physical activity intervention (Gehris, 2007; Jelalian et al., 2011, 2010, 2006).

Table 1: Study characteristics

Reference	Country	Sample size	Target group	Program content	Duration	Context	Health domain(s)	Outcome(s)	Type of outcome	Comment
Quasi-randomised trial										
Connelly (2012)	USA	i: 18 c: 18	13-16, ♀♂	Adventure-based counselling	1 day	Education	Mental and social	Active involvement (ca) + Cooperation (ca) + Coping with change (ca) + Internal control (ca)+ Leadership (ca)+ Open thinking (ca) + Overall efficiency (ca)+ Self-efficacy (ca)+ Stress coping (ca) + Time efficiency (ca)+	Health promotion outcome	
Jelalian, Mehlenbeck, Lloyd-Richardson, Birmaher, and Wing (2006)	USA	i:37 c:39	13-16, overweight, ♀♂	Adventure therapy + cognitive behavioural therapy	1 session per week, 16 weeks	Treatment/ Rehabilitation	Mental, social and physical	BMI (o) +* Peer rejection (ca) +* Self-perception (ca) +* Social support (ca) +*	Health and social outcomes and health promotion outcome	* no difference compared to control (group-based cognitive behavioural treatment with aerobic exercise)
Jelalian et al. (2010)	USA	i: 62 c: 56	13-16, overweight, ♀♂	Adventure therapy	1 session per week, 16 weeks	Treatment/ Rehabilitation	Physical	BMI (o) +* Waist circumference (o) +* Physical activity (o) +*, **	Intermediate health outcomes	* no difference compared to control (group-based cognitive behavioural treatment with aerobic exercise) ** MVPA averaged over three days
Jelalian, Sato, and Hart (2011)	USA	89 (i and c N.R.)	13-16, overweight, ♀♂	Adventure therapy	1 session per week, 16 weeks	Treatment/ Rehabilitation	Mental, social and physical	BMI (o) +* Peer rejection (ca) +* Social anxiety (ca) +* Self-perception (ca) +*	Health and social outcomes and health promotion outcome	* no difference compared to control (group-based cognitive behavioural treatment with aerobic exercise)

										treatment with aerobic exercise)
O'Brien and Lomas (2017)	England	i:103 c: 93	N.R., children from three schools, ♀♂	Outdoor personal development course + mind-set theory course	5 days	Education	Mental	Self-efficacy (ca) +* Resilience (ca) + Growth mind-set (ca) +	Health promotion outcome	* No difference compared to control group who partook in similar course but with no mind-set theory course.
White (2012)	England	i: 24 c: 24	13 (± 7 months), social and emotional challenges, ♀♂	Outdoor Education*	3 months	Education	Mental	Self-concept (ca) +	Health promotion outcome	* 1 month with 2 hours of preparatory classes on weekly basis at a school followed by five-day residential outdoor education from center and 3.5 days of backpacking in wilderness.
Cluster-randomised trial										
Zachor et al. (2017)	Israel	i: 30 c: 21	3,4-7,4, diagnosed with autism, ♀♂	Outdoor adventure	30 min weekly, over 13 weeks	Preschool/ Education	Social	Social functioning (c) +/-	Health and social outcome	
Cross-over trial										
Faber Taylor and Kuo (2009)	USA	17	7-12, diagnosed with ADHD, ♀♂	Walking	20 min	Treatment/ Rehabilitation	Mental	Cognitive performance (ct) +	Health promotion outcome	
Hohashi and Kobayashi (2013)	Japan	27	12-14, ♀	Seated relaxation and walking	15 min seated, 30 walking	Education	Mental	Salivary amylase activity (o) / Depressive mood (ca) / Fatigue (ca) + Tension and excitement (ca) + Refreshing mood (ca) / Anxious mood (ca) /	Health promotion outcome	

Mann (2007)	USA	35	13-17, at-risk, ♀	Outdoor adventure program*	Unclear. Min. 4 days	Treatment/ Rehabilitation	Mental and social	Self-confidence (ca) + Self-esteem (ca) + Perceived social support (ca) + Mattering (ca) + Identity (ca) +	Health promotion outcome	* Developed specifically for girls with risky behaviour
Reed et al. (2013)	England	75	11-12, ♀♂	Running	10-20 min	Education	Mental	Self-esteem (ca) / Enjoyment of running (ca) +	Health promotion outcome	
Schutte, Torquati, and Beattie (2017)	USA	67	4-8, ♀♂	Walking	20 min	Education	Mental	Working memory (ct) / Inhibitory control (ct) / Cognitive performance (ct) +	Health promotion outcome	
Wood et al. (2014)	England	60	♀: 13 (SD: 0.5) ♂: 12.9 (SD: 0.6)	Orienteering	20 min	Education	Mental and physical	Self-esteem (ca) +* Physical activity (o) +**	Intermediate health outcomes and Health promotion outcome	* no difference compared to orienteering in urban environment ** MVPA averaged, correlational
Controlled pre-post design										
American Institutes for Research (2005)	USA	i: 125 c: 109	N.R. (6.th grade students), at-risk, ♀♂	Outdoor science school*	5 days	Education	Mental and social	Cooperation (ca) + Conflict solving skills (ca)+ Self-esteem (t) + Problem solving (t) + Motivation for learning (t) + Academic performance (t) + Relationship to peers (t) + School behaviour (t) +	Health and social outcomes and health promotion outcome	* Curriculum-based with focus on hands-on learning, environment, and ecosystems.
Ang et al. (2014)	Singapore	i:76 c:60	13-18, truant behaviour, ♀♂	Outward Bound*	5 days	Education	Mental	Goal setting (ca) + Problem solving (ca) / School attendance (o) +	Intermediate health outcomes and Health promotion outcome	* Co-curricular activity.

Dettweiler, Becker, Auestad, Simon, and Kirsch (2017)	Germany	i:37 c: 11	11.23 (SD: 0.46), ♀♂	Education outside the classroom	1 day weekly over one school term	Education	Mental and physical	Cortisol (o)+ Physical activity (o) +*	Intermediate health outcomes and Health promotion outcome	* Longitudinal/ correlational comparison
Duerden, Widmer, Taniguchi, and McCoy (2009)	USA	i:45 c: 43	11-15, ♀♂	Adventure recreation	2 weeks	Education	Mental	Identity formation antecedents (ca) +	Health promotion outcome	
Fjørtoft (2004)	Norway	i:46 c:29	5-7, ♀♂	Free play	9 months	Preschool	Physical	Motor fitness (ct) +	Intermediate health outcomes	
Fuller, Powell, and Fox (2017)	England	i:12 c: 12	14-16, underachieving academically, ♀♂	Outdoor residential experiences	2 3-day sessions yearly, over 3 years	Education	Mental	Self-efficacy (c) + Academic performance (g) +	Health and social outcome and Health promotion outcome	
Furman and Sibthorp (2014)	USA	i: 57 c: 60	14-15, ♀♂	Outdoor adventure	14 days	After school activity	Social	Expedition behaviour (c) + Prosocial behaviour (c) +*	Intermediate health outcomes	
Gehris (2007)	USA	i: 27 c1: 13 c2: 14	N.R., 10 th grade technical students, ♀♂	Adventure education	24 sessions of 40 minutes over 44 days	Education	Mental and physical	Self-esteem (ca) +* Physical self-concept (ca) / Physical fitness (ct) /	Health promotion outcome and Intermediate health outcomes	* no difference compared to c1, but i and c1 improved more than c2 (c1: physical activity, c2: health education)
Guthrie (2004)	USA	i: 39 c: 33	6-17, mental or emotional disorders, ♀♂	Adventure therapy + cognitive behavioural therapy	2 hours weekly over 9 weeks	Treatment/ Rehabilitation	Mental	Problem Severity (m) / Functioning (m) /	Health and social outcome	

Hayhurst et al. (2015)a	New Zealand	i: 63 c: 63*	i: 16.55 c: 19.42, ♀♂**	Developmental voyage	10 days	Education	Mental	Resilience (ca) +	Health promotion outcome	* Psychology course ** Intervention participants nominated by high school. Reasons not stated.
Hayhurst et al. (2015)b	New Zealand	i: 72 c: 74	i: 16.51 c: 16.43, ♀♂	Developmental voyage	10 days	Education	Mental	Resilience (ca) + Self-esteem (ca) + Self-efficacy (ca) + Social effectiveness (ca) +	Health promotion outcome	* Participants nominated by high school. Reasons not stated.
Hunter et al. (2013)a	New Zealand	i:31 c: 31	16.48, ♀♂*	Developmental voyage	10 days	Education	Mental	Self-esteem (?) +	Health promotion outcome	* Participants nominated by high school. Reasons not stated.
Hunter et al. (2013)b	New Zealand	i:132 c: 264	i: 16.28 c: 17.25, ♀♂*	Developmental voyage	10 days	Education	Mental	Self-esteem (?) +	Health promotion outcome	* Participants nominated by high school. Reasons not stated.
Hunter et al. (2010)a	New Zealand	i:33 c: 33	i: 15,79 c: 19,69, ♀♂*	Developmental voyage	10 days	Education	Mental	Self-efficacy (ca) +	Health promotion outcome	* Participants nominated by high school. Reasons not stated.
Hunter et al. (2010)b	New Zealand	i:82 c: 31	i: 15,79 c: 15, ♀♂*	Developmental voyage	10 days	Education	Mental	Self-efficacy (ca) +	Health promotion outcome	* Participants nominated by high school. Reasons not stated.
Kafka et al. (2012)a	New Zealand	i:27 c: 33	i: 16,21 c: 16,25, ♀♂*	Developmental voyage	10 days	Education	Mental and social	Self-esteem (ca) + Gender prejudice (ca) +	Health promotion outcome	* Participants nominated by high school. Reasons not stated.
Kafka et al. (2012)b	New Zealand	i:89 c: 53	i: 14-18 c: 15-18, ♀♂*	Developmental voyage	10 days	Education	Mental and social	Self-esteem (ca) +	Health promotion outcome and Intermedi	* Participants nominated by high school. Reasons not stated.

									ate health outcomes	
Larson (2007)	USA	i:31 c: 30	9-17, behavioural issues, ♀♂	Adventure camp	5 days	Treatment/ Rehabilitation	Mental	Self-concept (ca) +/*	Health promotion outcome	* Only significantly different from control for 9 to 11 year-olds
Margalit and Ben-Ari (2014)	Israel	i:64 c: 29	14-16 at-risk, ♂	Wilderness therapy	Unclear*	Treatment/ Rehabilitation	Mental	Self-efficacy (ca) +/ Cognitive autonomy (ca) +/	Health promotion outcome	* 10 preparatory meetings, 4 days backpacking, 2 evaluation meetings
Orren and Werner (2007)	USA	i:67 c: 76	14.64 (SD: 1.91), ♀♂	Wilderness program	1 day, 2 nights	Various	Mental	Self-concept (ca,p,l) / Internalising and externalising behaviours (ca,p,l) /	Health promotion outcome	
Romi & Kohan (2004)	Israel	i: 36 c1: 88 c2: 33	15-18, drop-outs, ♀♂	Wilderness adventure therapy	6 days	Treatment/ Rehabilitation	Mental	Self-esteem (ca) + Locus of control (ca) +/	Health promotion outcome	
Within-subjects with no cross-over										
Roe and Aspinall (2011)	Scotland	18	11*, ♀♂	Forest school	5 hours	Education	Mental	Mood (ca) + Reflection on personal development (ca) /	Health promotion outcome	* participants included children with and without behavioural problems
van den Berg and van den Berg (2011)	Netherlands	12	9-17, diagnosed with ADHD, ♀♂	Stay at care farms	1 hour	Treatment/ Rehabilitation	Mental	Cognitive performance (ct) + Mood (ca) –	Intermediate health outcomes and Health promotion outcome	

c: control group, c1: control group number 1, c2: control group number 2, i: intervention group, N.R.: not reported, * and ** refers to associated comment in the column on the far-right side.

+: Significant difference between natural and control condition was reported, /: No significant difference was reported, +/-: Findings were mixed

ca = questionnaire filled out by child or adolescent, ct = test taken by child, test, g = grade scores, l = outing leader filled out questionnaire about the participating child or adolescent, m = mental health professional filled out questionnaire about the participating child or adolescent, o = objective measurement from device or registers, p = primary caregiver filled out questionnaire about the participating child or adolescent, t = teacher filled out questionnaire about the participating child or adolescent

Across all outcomes, 60% ($n = 56$) were improved pre to post immersive nature-experience compared to control conditions and groups. 18% ($n = 17$) of all the outcomes were improved pre to post, but no more than the control conditions and groups, and the remaining 22% ($n = 20$) indicated mixed or insignificant findings. In the following, we present findings and quality of evidence assessments at an outcome level.

Mental health

Figure 2 displays the outcomes investigated twice or more frequently in separate identified controlled studies. Amongst these outcomes, 65.7% ($n = 23$) were improved following immersive nature-experience, 8.6% ($n = 3$) were improved, but not various control conditions and the remaining 25.7% ($n = 9$) indicated mixed or insignificant findings. Outcomes investigated less frequently in controlled studies are included in Table 1.

Figure 2. Overview of mental health outcomes and results.

Self-esteem. Out of 11 unique studies, eight studies (from six publications) found that nature-based programmes improved participants' self-esteem more than comparison conditions (American Institutes for Research, 2005; Hayhurst et al., 2015; Hunter et al., 2013; Kafka et al., 2012; Mann, 2007; Romi and Kohan, 2004). In one study, the children's self-esteem increased following orienteering in a natural environment but no more than pre to post orienteering in the urban environment (Wood et al., 2014). Gehris (2007) found that 44 days of adventure education improved the 10th grade pupils' self-esteem more than the control group that had undergone a health education programme, but not more than the control group that participated in a physical activity programme. In another study, no difference was observed when comparing exercise in a natural versus built environment (Reed et al., 2013). Due to a serious risk of bias across studies, the quality of the evidence was considered low (see Table 2 for risk of bias assessments for between-subject studies, Table 3 for within-subject studies, and Table 4 for outcome level quality for mental health outcomes).

In supplement to the controlled studies, pre-post studies without a control group indicated positive associations between improved self-esteem and a dog sledding expedition for children and adolescents with cancer (Vallet et al., 2015); an outward bound course for female students (Wang et al., 2006); wilderness expedition for adolescents (Barton et al., 2016); residential wilderness therapy for 14 to 16 year-old males (Gillespie and Allen-Craig, 2009); and a ten-day developmental voyage on a ship (Kafka et al., 2012). No significant difference pre to post wilderness therapy was occasionally observed (Bowen et al., 2016; Hinds, 2011; O'Shea, 2008). There was also some mixed findings where some types of wilderness expeditions were associated with increased self-esteem and some were not (Vissell, 2004).

Self-efficacy. Five of seven unique studies (in four publications) concluded that immersive nature-experiences lead to increases in self-efficacy (Connelly, 2012; Fuller et al., 2017; Hayhurst

et al., 2015; Hunter et al., 2010). O'Brien and Lomas (2017) compared the development in self-efficacy amongst pupils in grades six to nine who partook in outdoor personal development course and a mind-set theory course with pupils who only participated in an outdoor personal development course and found increases in both groups. One study reported that only subdivisions of the self-efficacy scales were significantly improved in the intervention group (Margalit and Ben-Ari, 2014). Due to serious risk of bias across studies, the quality of the evidence was considered low.

Pre-post studies with no control indicated positive associations between different types of shorter and longer term outdoor education programmes and self-efficacy for adolescents (Lokos, 2013; McGowan, 2016; Mutz and Müller, 2016; Richmond, 2016; Walsh, 2009). A single pre-post study reported that no difference could be observed (O'Shea, 2008).

Self-concept. One study found that a three month outdoor education programme increased self-concept (White, 2012b), whereas a five-day adventure camp only increased the youngest children's (seven to 11 year-old) self-concept (Larson, 2007). Two quasi-randomised studies found an increase in positive self-concept in overweight adolescents over the course of a 16-week adventure therapy programme, but that the increase was not different from the development displayed by control participants who took part in an alternative exercise programme (Jelalian et al., 2011, 2006). No effect could be observed following 44 days of adventure education in comparison to two control groups consisting of either a physical activity or health education programme (Gehris, 2007), nor a one-day wilderness programme (Orren and Werner, 2007). Due to serious risk of bias and indirectness stemming from the lack of a no treatment control group for three of the studies (Gehris, 2007; Jelalian et al., 2011, 2006), the quality of the evidence was considered low.

A supplementary study reported that adolescents' self-awareness was increased over the course of a two-day camp (Ee and Ong, 2014).

Resilience. Two individual studies from the same publication (Hayhurst et al., 2015) including different populations reported improvements in resilience amongst high school students following a ten-day voyage. O’Brien and Lomas (2017) found an increase amongst pupils in grades six to nine who participated in an outdoor personal development course in conjunction with a mind-set theory course, but not pupils who only partook in an outdoor personal development course. The quality of the evidence was considered low.

Supplementary pre-post studies reported that adolescent out-patients of a regional state-based adolescent mental health service reported slightly higher levels of resilience after a ten week wilderness therapy programme (Bowen et al., 2016). Likewise, aboriginal adolescents reported higher levels of resilience immediately following a ten-day outdoor adventure leadership course, but not after a year (Ritchie and Ritchie, 2014). Amongst 14 to 16 year-old males described as at-risk, resilience was increased over the course of a five-week residential wilderness therapy (Gillespie and Allen-Craig, 2009). Youth offenders’ reported levels of resiliency were unchanged from before to after a 21-day wilderness adventure programme (Walsh, 2009).

Problem solving. One study found that problem solving was improved upon a five-day outdoor science school programme (American Institutes for Research, 2005). An alternative five-day outward bound, co-curricular activity did not lead to significant differences between groups (Ang et al., 2014). The quality of the evidence was considered low.

One supplementary pre-post study reported an increase in 13 year-old pupils’ problem solving competences pre to post a 12-day outdoor education programme (Sproule et al., 2013). Likewise, 14 to 16 year-old males’ problem solving was increased over the course of a five-week residential wilderness therapy (Gillespie and Allen-Craig, 2009).

Academic performance. Two studies reported that at-risk and underachieving participants' academic performances were improved following a five-day outdoor science school programme (American Institutes for Research, 2005), and a biannual three-day outdoor residential experience distributed over the course of three years (Fuller et al., 2017). Due to risk of bias, the quality of the evidence was considered low.

We identified one supplementary pre-post study. The academic performance of 13 to 18 year-old males, but not females, with emotional and behavioural challenges was increased from pre to post 21 days of wilderness therapy (Harper et al., 2007).

Cognitive performance. Three within-subjects studies indicated that cognitive performance was enhanced after walking (Faber Taylor and Kuo, 2009; Schutte et al., 2017) and after various types of physical activity (van den Berg and van den Berg, 2011) in natural environments compared to urban environments. None of the studies generated pre-intervention measures and therefore compared post scores with no control for baseline differences. The quality of the evidence was considered low owing to risk of bias and imprecision due to small sample sizes.

In a supplementary observational study, reported concentration scores were higher amongst children participating in a nature kindergarten than children enrolled in a mainstream kindergarten (Vigsø and Nielsen, 2006). Additionally, school pupils reported higher levels of concentration and memory in relation to education outside the classroom compared to regular, classroom-based teaching (Mygind, 2005). Amongst 17 to 19 year-old bachelor students, creativity scores were higher when tested during a six-day canoeing trip compared to an indoor control condition (Ferraro, 2015).

Mood. Children's mood was improved more over the course of five hours of forest school than a regular school day (Roe and Aspinall, 2011). No difference was observed in mood after one

hour of various types of physical activity in natural environments compared to urban environments (van den Berg and van den Berg, 2011), nor was depressive, refreshing and anxious mood differentially affected by 15 minutes of seated relaxation or 30 minutes of walking in natural versus urban environments (Hohashi and Kobayashi, 2013). However, fatigue, tension, and excitement were improved amongst the adolescent girls (Hohashi and Kobayashi, 2013). Whereas Hohashi and Kobayashi (2013) and Roe and Aspinall (2011) included baseline measures and compared change scores across environments, van den Berg and van den Berg (2011) did not include baseline scores. Due to a high risk of bias across the studies and imprecision introduced by small sample sizes, the quality of the evidence was rated low.

Four correlational studies with different adolescent populations and types of wilderness and adventure therapy reported that scores for depression were improved: adolescent out-patients of a regional state-based adolescent mental health service reported slightly lower levels of depression after a ten-week wilderness therapy programme (Bowen et al., 2016). Adolescents with diagnosed depression reported improvements in levels and prevalence of depression following a 21-day wilderness therapy programme (Norton, 2007). Likewise, under-resourced urban adolescents aged 13 to 18 reported improvements in levels and prevalence of depression over the course of a seven-to eight-day expedition (Norton and Watt, 2014). In an evaluation of three types of wilderness therapy programmes, only one was correlated with improvement in levels of depression amongst at-risk youth (Vissell, 2004). The aggregate measure ‘intrapersonal distress’, i.e. emotional distress including anxiety, depression, fearfulness, hopelessness, and self-harm., was unchanged amongst young offenders over the course of on average 108 days (ranging from 47 to 263 days) of wilderness expedition and other activities (Russell, 2006). The same measure was improved amongst adolescents struggling with emotional, behavioural and substance-related problems after

on average 82.2 days of a residential outdoor behavioural healthcare treatment programme (DeMille, 2015) and on average 64.7 days of wilderness therapy (Bettmann et al., 2013).

Table 2: Risk of bias in controlled, between-subject studies

	Random sequence generation*	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other bias
Connelly (2012)	+	?	?	?	-	+	+
Jelalian et al. (2006)	?	?	?	?	+	-	+
Jelalian et al. (2010)	-	?	?	?	-	-	?
Jelalian, Sato, and Hart (2011)	-	?	?	?	-	-	?
O'Brian and Lomas (2017)	?	-	-	?	?	-	-
White (2012)	?	?	?	?	-	-	+
Zachor et al. (2017)	-	?	?	?	-	-	?
American Institutes for Research (2005)	+	?	?	?	-	-	+
Ang et al. (2014)	?	?	?	?	-	-	-
Dettweiler et al.(2017)	?	+	+	?	-	-	+
Duerden et al. (2009)	+	?	?	?	?	-	-
Fjørtoft (2004)	?	?	?	?	-	-	+
Fuller et al. (2017)	?	?	?	?	-	?	-
Furman and Sibthorp (2014)	+	?	?	?	-	-	?
Gehris (2007)	+	?	?	?	-	-	+
Guthrie (2004)	+	+	?	?	-	-	-
Hayhurst et al. (2013)a	+	?	?	?	-	-	-
Hayhurst et al. (2013)b	?	?	?	?	-	-	-
Hunter et al. (2013)a	+	?	?	?	?	-	-
Hunter et al. (2013)b	?	?	?	?	?	-	-
Hunter et al. (2010)a	?	?	?	?	?	-	-

	Random sequence generation*	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other bias
Hunter et al. (2010)b	?	?	?	?	?	-	-
Kafka et al. (2012)a	?	?	?	?	?	-	-
Kafka et al. (2012)b	?	?	?	?	?	-	-
Larson (2007)	+	?	?	?	-	-	-
Margalit and Ben-Ari (2014)	?	?	?	?	-	-	-
Orren and Werner (2007)	?	?	?	?	+	-	-
Romi and Kohan (2004)	+	?	?	?	-	-	-

-: low, ?: unclear, +: high risk of bias

* For non-randomised studies, the item indicated whether other attempts than randomisation had been using to produce comparable groups and whether descriptive statistics to support that groups were comparable had been presented.

Table 3: Risk of bias in within-subjects studies

	Appropriate cross-over design	Randomised treatment order	Carry-over effect	Unbiased data	Allocation concealment	Blinding	Incomplete outcome data	Selective outcome reporting	Other bias
Faber Taylor and Kuo (2009)	-	?	-	?	?	-	?	?	+
Hohashi and Kobayashi (2013)	-	?	?	?	?	?	-	-	?
Mann (2007)	+	?	?	-	?	?	-	-	+
Schutte et al. (2017)	-	?	?	?	?	?	?	-	+
Wood et al. (2014)	-	-	?	-	?	?	?	-	-
Reed et al. (2013)	-	?	-	?	?	?	-	-	?
Roe and Aspinall (2011)	N.A.	N.A.	?	?	N.A.	?	-	-	-
van den Berg and van den Berg (2011)	N.A.	N.A.	?	?	?	?	-	-	-

-: low, ?: unclear, +: high risk of bias

Table 4: Quality of evidence, mental health outcomes

Outcome	Nr. Studies	References	Risk of bias	Inconsistency	Indirectness	Imprecision	Overall
Self-esteem	11	(American Institutes for Research, 2005; Gehris, 2007; Hayhurst et al., 2015; Hunter et al., 2013; Kafka et al., 2012; Reed et al., 2013; Wood et al., 2014)	Serious	Ok	Ok	Ok	Low
Self-efficacy	7	(Connelly, 2012; Fuller et al., 2017; Hayhurst et al., 2015; Hunter et al., 2010; Margalit and Ben-Ari, 2014; O'Brien and Lomas, 2017)	Serious	Ok	Serious	Ok	Low
Self-concept	6	(Gehris, 2007; Jelalian et al., 2011, 2006; Larson, 2007; Orren and Werner, 2007; White, 2012b)	Serious	Serious	Serious	Ok	Low
Resilience	3	(Hayhurst et al., 2015; O'Brien and Lomas, 2017)	Serious	Ok	Serious	Ok	Low
Problem solving	2	(American Institutes for Research, 2005; Ang et al., 2014)	Serious	N.A.	Ok	Ok	Low
Academic performance	2	(American Institutes for Research, 2005; Fuller et al., 2017)	Serious	N.A.	Ok	Ok	Low
Cognitive performance	3	(Faber Taylor and Kuo, 2009; Schutte et al., 2017; van den Berg and van den Berg, 2011)	Serious	Ok	Ok	Serious	Low
Mood	3	(Hohashi and Kobayashi, 2013; Roe and Aspinall, 2011; van den Berg and van den Berg, 2011)	Serious	Ok	Ok	Serious	Low

Ok: indicates that no serious issues were detected, serious: indicates that serious issues were detected, very serious: indicates that very serious issues were detected, N.A.: Not applicable due to limited number of studies

Table 5: Quality of evidence, physical health outcomes

Outcome	Nr. studies	References	Risk of bias	Inconsistency	Indirectness	Imprecision	Overall
BMI	3	(Jelalian et al., 2011, 2010, 2006)	Serious	Ok	Very serious	Ok	Low
Cortisol, salivary amylase	2	(Dettweiler et al., 2017; Hohashi and Kobayashi, 2013)	Serious	N.A.	Ok	Serious	Low

Ok: indicates that no serious issues were detected, serious: indicates that serious issues were detected, very serious: indicates that very serious issues were detected, N.A.: Not applicable due to limited number of studies

Table 6: Quality of evidence, social health outcomes

Outcome	Nr. studies	References	Risk of bias	Inconsistency	Indirectness	Imprecision	Overall
Relational: Social support, relationship to peers, peer rejection, social anxiety, social functioning	5	(American Institutes for Research, 2005; Jelalian et al., 2011, 2006; Mann, 2007; Zachor et al., 2017)	Serious	Serious	Ok	Ok	Low
Skills: Cooperation, conflict solving skills, leadership	2 (2 outcomes in 2 studies)	(American Institutes for Research, 2005; Connelly, 2012)	Serious	N.A.	Ok	Ok	Low
Behavioural: School, expedition and prosocial behaviour	3 (2 outcomes in one study)	(American Institutes for Research, 2005; Ang et al., 2014; Furman and Sibthorp, 2014)	Serious	Ok	Ok	Serious	Low

Ok: indicates that no serious issues were detected, serious: indicates that serious issues were detected, very serious: indicates that very serious issues were detected, N.A.: Not applicable due to limited number of studies

Physical health

The number of identified controlled studies exploring benefits to physical health were limited ($n = 5$). The findings are presented below for the individual outcomes.

BMI. Across three quasi-randomised studies, body mass index (BMI) decreased over the course of a 16-week adventure therapy programme, but the improvement did not differ significantly from the comparison group (Jelalian et al., 2011, 2010, 2006). Due to serious risk of bias and indirectness stemming from the lack of a no-treatment control group, the quality of the evidence was considered low.

One supplementary observational study found that youth in the sample developed towards a more healthy weight and BMI or were able to maintain at a healthy level while participating in an outdoor behavioural healthcare programme (DeMille et al., 2014). Adolescent participants were both underweight, normal weight, and overweight; and partook for 73 days, on average. Similar changes towards healthy weight and BMI were found amongst participants enrolled in residential wilderness therapy after on average 79.8 days (Tucker et al., 2016).

Psychophysiological stress. Cortisol levels decreased over a day of education outside the classroom (Dettweiler et al., 2017), but no difference could be observed when comparing seated relaxation and walking in natural versus urban environments (Hohashi and Kobayashi, 2013). Due to risk of bias and imprecision, the latter introduced by small sample sizes, we considered the quality of the evidence low.

We did not identify observational studies that had investigated psychophysiological stress outcomes. One study reported improvements in perceived stress amongst primary school pupils pre to post a nine-day hike and university students after an eight-day wilderness expedition (Mutz and Müller, 2016).

Physical activity. Perhaps unsurprisingly, physical activity was mainly used as an acute and highly context-dependant indicator of bodily movement during immersive nature-experience. As such, no studies compared physical activity before and after interventions. We therefore briefly report the correlational evidence; 20 minutes of orienteering was associated with enhanced levels of moderate to vigorous physical activity (MVPA) (Wood et al., 2014) and a number of studies found that a day of education outside the classroom conducted in green settings, (Dettweiler et al., 2017; Grønningsæter et al., 2007; Mygind, 2016, 2007) and forest school (Lovell, 2009) was associated with higher levels of MVPA than regular school. Averaged over three seasons, children were expected to spend 11.5 minutes longer in MVPA per two hour unit (Dettweiler et al., 2017). The average daily minutes of MVPA during a three-day period was not higher when comparing an adventure therapy programme with an exercise programme (Jelalian et al., 2010).

Social health

Figure 3 displays the outcomes investigated in separate identified controlled studies. 60% ($n = 9$) of these social health outcomes were improved following immersive nature-experience, but not various control conditions, 33.3% ($n = 5$) was improved, but no more than control conditions and the remaining 6.7% ($n = 1$) indicated mixed findings.

Relational indicators. At-risk girls undergoing an outdoor adventure programme reported an increase in perceived social support (Mann, 2007). Two unique groups of overweight adolescents reported an enhanced perception of social support and decreased perceived peer-rejection (Jelalian et al., 2006) and decreased perceived peer-rejection and social anxiety (Jelalian et al., 2011) following 16-week adventure therapy programmes, but improvements were not significantly different from the control groups. One study reported an improvement in the

participating 6th grade pupils' relationships to peers upon a five-day outdoor science school programme (American Institutes for Research, 2005). Children aged three to seven diagnosed with autism displayed mixed social functioning outcomes following a 13-week outdoor adventure programme including 40 min sessions on a weekly basis (Zachor et al., 2017). The quality of the evidence for effects on indicators of social support, relationships to peers and peer-rejection, and social anxiety and social functioning were low.

Figure 3. Overview of social health outcomes and results.

Two supplemental pre-post studies indicated that family function improved over the course of a 21-day wilderness therapy program for adolescents with emotional, behavioural, and substance use problems (Harper et al., 2007), and adolescent out-patients with mixed mental health issues who completed a ten-week, manualised wilderness therapy intervention (Bowen et al., 2016). Likewise, under-resourced urban adolescents aged 13 to 18 reported improvements in family support over the course of a seven- to eight-day expedition (Norton and Watt, 2014). Adolescents with diagnosed depression reported lower levels of family conflict post a 21-day wilderness therapy programme

(Norton, 2007). In one study, some indicators of family function reports were improved and others not following 21 days of wilderness therapy (Harper et al., 2007). Likewise, some parent and peer attachment indicators were improved and others not after seven weeks of wilderness therapy amongst 14 to 17 year-old adolescents (Bettmann and Tucker, 2011). A one-week outdoor education programme was also found to be associated with an increased sense of social belonging amongst adolescents (Richmond, 2016). Primary school pupils reported improved levels of social relations, for example, levels of teasing and quarrelling, influence on play, and helping behaviours, when participating in education outside the classroom in natural environments compared to classroom-based teaching (Mygind, 2009). The aggregate measure ‘interpersonal relations’ (i.e. relationship with parents, other adults, and peers, and the attitude toward others, interaction with friends, aggressiveness, arguing and defiance) was improved amongst young offenders over the course of on average 108 days (ranging from 47 to 263 days) wilderness expedition and other activities (Russell, 2006). Interpersonal relations were also improved amongst adolescents struggling with emotional, behavioural and substance-related problems after on average 82.2 days of a residential outdoor behavioural healthcare treatment programme (DeMille, 2015) and on average 64.7 days of wilderness therapy (Bettmann et al., 2013).

Skill indicators. Adventure-based counselling was found to enhance adolescents’ cooperation and leadership skills (Connelly, 2012). Likewise, at-risk pupils taking part in outdoor science school reported increased cooperation and conflict solving skills (American Institutes for Research, 2005). The quality of evidence was considered low.

One supplementary pre-post study reported an increase in 13 to 16 year-old female pupils’ leadership and interpersonal skills after a five-day outward bound course (Wang et al., 2006), and another study reported enhancements in 13 year-old pupils’ collaboration and communication skills pre to post a 12-day outdoor education programme (Sproule et al., 2013). Likewise, McGowan

(2016) reported that adolescents' self-reported interpersonal leadership skills were improved following an outdoor education semester. Secondary pupils aged, on average, 14.1 years old reported that their social awareness, self-management and relationship management was improved over the course of a two-day camp (Ee and Ong, 2014).

Behavioural indicators. School behaviours were improved amongst at-risk 6th grade pupils following a five-day outdoor science school programme (American Institutes for Research, 2005) and school attendance likewise improved after a five-day outward bound course for adolescents with truant tendencies (Ang et al., 2014). While adolescents participating in an after-school outdoor residential experience displayed larger improvements in expedition behaviours than the control group, the same could not be observed for general prosocial behaviours which, although improved, did not differ from the control group (Furman and Sibthorp, 2014). The quality of the evidence was deemed low due to serious risk of bias and imprecision.

One supplemental pre-post studies indicated that adolescent behaviour in relation to, for example, following house rules, communicating with parents, violence, alcohol and substance abuse improved over the course of a 21-day wilderness therapy program for adolescents with emotional, behavioural and substance use problems (Harper et al., 2007). Some aspects of at-risk youths' behavioural conduct were improved following an outdoor adventure programme involving 15 activity days over a period of ten to 12 weeks (Bowen and Neill, 2016). No statistically significant change could be observed in problem behaviours, i.e. conduct disorder, socialised aggression, attention problems/immaturity, anxiety/withdrawal, psychotic behaviour and motor tension/excess, amongst 10 to 18 year-old girls after a one-week summer educational outdoor adventure program (O'Shea, 2008). Jones et al. (2004) and Walsh (2009) found no difference in recidivism rates when comparing juvenile delinquents who had participated in a residential wilderness therapy programme with participants who had undergone group home programmes. The aggregate measure 'social

problems', i.e. problematic behaviours that are socially related, including truancy, sexual problems, running away from home, destruction of property and substance abuse, was improved amongst young offenders after wilderness expedition and other activities (Russell, 2006). Social problems were likewise improved amongst participants in a residential outdoor behavioural healthcare treatment programme (DeMille, 2015) and wilderness therapy (Bettmann et al., 2013).

Risk of bias

This systematic review included 84 unique publications of which 32 publications included one or more controlled studies that were subjected to quality assessment. Within these 32 publications, 28 studies followed controlled, between-subjects designs and eight within-subjects designs. Figure 4 and 5 displays risk of bias across studies in between- and within-subjects studies, respectively.

Items relating to allocation randomisation and concealment, blinding, incomplete outcome data and selective outcome reporting were assessed for both between- and within-subjects studies. Out of the 28 between-subjects studies, seven reported that allocation of participants to conditions was randomised (see Table 2). For three of these studies, the methods described were not fully random at the individual level with two studies dividing participants according to gender and subsequently allocating participants by an undescribed random approach (Jelalian et al., 2011, 2010) and one study utilising a cluster-randomised approach (Zachor et al., 2017), yet the allocation methods were considered to produce comparable groups. Four studies did not describe the means by which allocation was randomised and the risk of bias was considered unclear (Jelalian et al., 2006; O'Brien and Lomas, 2017; White, 2012) or high (Connelly, 2012).

Figure 4. Risk of bias across between-subjects studies.

* For non-randomised studies, the item indicated whether other attempts than randomisation had been using to produce comparable groups and whether descriptive statistics to support that groups were comparable had been presented.

Figure 4. Risk of bias across within-subjects studies.

In the remaining 21 between-subjects studies, risk was considered in regard to reported attempts to achieve comparability between intervention and control groups and rigor in the description of demographic comparability. Nine studies were considered to have a high risk of biased allocation when the allocation method was not described or speculated to lead to differences in intervention and control groups, and descriptive statistics were either missing or indicated differences between intervention and control groups that could influence study results. Twelve studies posited an unclear risk of bias when allocation method was not described in much detail or no or limited descriptive statistics were reported.

Amongst the eight within-subjects studies, most ($n = 5$) did not describe the way by which randomisation to condition order was made and the risk of bias was considered unclear (see Table 3). Two studies (Roe and Aspinall, 2011; van den Berg and van den Berg, 2011) did not use a cross-over design. Consequently, the item was not applicable for these two studies. Only one within-subjects study (Wood et al., 2014) was considered to entail a low risk of biased allocation to interventions due to sequence generation.

Most between- and within-subjects studies did not describe whether participants were aware of group or condition allocation prior to the intervention. Two between-subjects studies were considered under high risk of participants having prior knowledge of group allocation, since the participants were familiar with their own and the control groups' allocation (Dettweiler et al., 2017; Guthrie, 2004). Likewise, the extent to which participants were blinded to research question and outcome assessors to group allocation was generally poorly described and considered unclear. In a single between-subjects study, personnel and participants were aware of the research aims (Dettweiler et al., 2017). Only one within-subjects study explicitly described that participants and personnel were blinded to the research question and outcome assessors to group allocation (Faber Taylor and Kuo, 2009).

The risk of incomplete outcome data and selective reporting was considered low in approximately 60% of both between- and within-subjects studies. The risk of incomplete outcome data and selective reporting was deemed unclear in the rest of the studies with the exception of two between-subjects studies that were considered under high risk of incomplete outcome data (Jelalian et al., 2006; Orren and Werner, 2007) and one of selective reporting (Connelly, 2012).

Items only assessed for within-subjects studies included whether the cross-over design was appropriate for the outcomes used, if a carry-over effect was evaluated and controlled for, and presence of unbiased data. Most studies utilising outcomes that were hypothesised to be acutely influenced by the exposures, appropriately utilised the cross-over design. One study (Mann, 2007) included measures that were intended to extend beyond the duration of the measures, thereby also introducing a risk of a carry-over effect which was not evaluated. Only one study (Faber Taylor and Kuo, 2009) explicitly evaluated the risk of carry-over effects, and on this background excluded several outcomes that were found to be contaminated by carry-over effects. Descriptive data were frequently unavailable for part of the outcomes, or only analytical results were provided. Two studies (Mann, 2007; Wood et al., 2014) were considered at low risk of biased data.

Other sources of potential bias included sampling bias stemming from self-selection by the participants or participants' caretakers into the intervention and/or control group (American Institutes for Research, 2005; Ang et al., 2014; Dettweiler et al., 2017; Duerden et al., 2009; Fjørtoft, 2004; Furman and Sibthorp, 2014; Gehris, 2007; Jelalian et al., 2011, 2010, 2006; Larson, 2007; Orren and Werner, 2007; Romi and Kohan, 2004) and from large quantities of non-responses or missing data (American Institutes for Research, 2005; Hohashi and Kobayashi, 2013). We also encountered risk of analytical bias where a clustered design was used but statistical methods did not account for this (American Institutes for Research, 2005; Fjørtoft, 2004; Zachor et al., 2017), where simplified statistical methods had been used (Fjørtoft, 2004; Fuller et al., 2017; Larson, 2007;

White, 2012b), and where comparisons between groups did not account for baseline differences in the measures (Connelly, 2012).

Discussion

The aims of this systematic review were to investigate 1) how immersive nature-experiences influence mental, physical and social health outcomes in children and adolescents, and 2) the quality of the evidence at an outcome level.

The general tendency across outcomes indicated that immersive nature-experiences provide immediate benefits to a range of mental, physical and social health outcomes. Across all outcomes, 60% ($n = 56$) indicated that the outcome was improved after participation in the intervention whereas no such effect could be observed under the control condition. Furthermore, 18% ($n = 17$) indicated that an improvement in both the intervention and control group was observed, and 22% ($n = 20$) were reports of mixed or insignificant findings. When focusing on studies in which a control group had been included, outcomes such as self-esteem, self-efficacy, resilience, academic performance, cognitive performance and social skills and behaviours were predominantly enhanced by immersive nature-experiences. Several outcomes, i.e. self-concept, problem solving, mood, relational indicators, BMI and psychophysiological stress, were associated with an equal or greater number of studies reporting non-conclusive or mixed findings to significant benefits. Overall, due to risk of bias and issues relating to imprecision, the quality of the evidence at an outcome level was low in the context of the quality assessment scheme used here (see the Strengths and limitations section for a more elaborate discussion). While immersive nature-experiences generally supported a range of mental, physical and social health outcomes among children and adolescents, and no

harmful events were reported, the literature serves only as a conditional basis on which to make recommendations for practice.

Tillmann et al. (2018) divided studies of nature interventions according to three types of nature interaction, i.e. ‘accessibility’ to green space, (passive or incidental) ‘exposure’ to nature, and (active use of and) ‘engagement’ with a natural environment. In the present systematic review, we excluded studies under the accessibility category, given that accessibility to green space would not necessarily result in use of the environment. We included engagement and parts of the exposure type interventions, e.g. not exposures or views during transport, at school or home. On the basis of the distribution of significant positive findings to non-significant findings, Tillmann et al. (2018) found that more studies in the engagement category indicated non-significant findings than positive findings, and concluded that the association with mental health was inconclusive. However, our results indicated that more studies of the engagement type interventions reported positive, significant findings (65.7%, $n = 23$) than mixed or insignificant in the mental health domain, when focusing exclusively on studies using controlled designs. These provide a stronger basis on which to identify the source of changes in the studies, and as such, we argue that there is conditional support for benefits for children and adolescents on self-esteem, self-efficacy, resilience and academic and cognitive performance, from immersion in nature. Benefits for outcomes such as self-concept, problem solving and mood were inconclusive. In addition, social skill-oriented and behavioural indicators were improved, although the categories included different outcomes.

Various factors are likely to be involved with the more inconclusive findings relating to, for example, self-concept, problem solving and mood, but an intuitive feature relates to the influence of intervention time span. For both outcomes self-concept and mood, for example, findings from longer-term interventions indicated beneficial outcomes, whereas no differences could be observed following short-term interventions. For example, children’s mood was improved comparatively

more after five hours of forest school than a regular school day (Roe and Aspinall, 2011), but no differences could be observed after 15, 30 (Hohashi and Kobayashi, 2013) or 60 minutes of exposure (van den Berg and van den Berg, 2011). A three month outdoor education programme increased self-concept (White, 2012b), whereas a five-day adventure camp only provided improvements amongst certain age groups (Larson, 2007) and a one-day wilderness programme made no differences at all (Orren and Werner, 2007). Naturally, caution should be taken for putting too much emphasis on the implications of the findings when stemming from such a small number of studies conducted with different target groups and types of interventions. Still, the importance of time, in relation to various outcomes, may be a subject worth exploring in future meta-analyses of similar types of nature-experience. At present, the evidence is premature as a basis for conclusions pertaining to optimal or minimum time spent in nature, in particular considering the heterogeneity of individual, situational and contextual factors at play in individual studies that interact to provide different outcomes. Other factors that may be related to the inconclusive findings relate to quality of the evidence, e.g. risk of bias, and across studies heterogeneity that will be discussed further in the following sections.

Strengths and limitations

This review presents a comprehensive overview of the research concerning children, nature and mental, physical and social health, combined with an evaluation of the quality of the research at a study and outcome level. Previous reviews provided much needed insights into studied relationships between children, nature and health, but compiled various types of designs, interventions, and/or outcomes (Faber Taylor and Kuo, 2006; Holland et al., 2018; McCurdy et al., 2010; Muñoz, 2009; Tillmann et al., 2018). Although we focused exclusively on immersive nature-experience and distinguished between types of both designs and outcomes, the research was spread across diverse intervention characteristics (e.g. activity, pedagogical and instructional approach,

duration or type of natural environment), target groups (e.g. diagnosed or typically developing individuals), contexts (e.g. recreation, education or treatment), and control conditions (e.g. no treatment, short nature exposure or alternative treatment). As such, we did not consider the research suited for meta-analyses, which, we argue, requires more streamlining to avoid simplified conclusions and recommendations.

In addition to these variations in the reviewed studies, study and outcome level quality could contribute to imprecise study findings. Lack of clarity and issues relating to risk of bias in the individual studies were frequent reasons for downgrading assessments of the quality of the evidence at an outcome level (see Tables 4, 5, and 6). Here, it is important to highlight that unclear ratings could concern either undetailed or unclear reporting, within the context of the research aims and quality indicators utilised in this review, and actual research conduct. However, it remains that there are some uncertainties regarding the quality of the evidence and consequently, the confidence with which recommendations for practice can be made. In several studies, there was a high or unclear risk of poor intervention and control group comparability: randomised group or condition allocation was only used in a small subset of studies and descriptive demographic statistics to indicate the actual composition of the groups were seldom reported. Several studies were also based on participants who self-selected into the intervention group. In congruence with other potential sources of bias, such as blinding participants from research question and outcome assessors from group allocation, of which the impact was unclear, much of the research could to some extent be biased. As was also illustrated in Figures 4 and 5, many risk of bias items were assessed as unclear. Finally, sample sizes were generally rather small.

While it may seem tempting to conclude that the research field suffers under either a general lack of transparency in reporting or low research standards, or even both, a contextualisation and elaboration is required. Elsewhere, the evidence for the effects of various psychosocial, behavioural

interventions oriented towards symptom reduction in children and adolescents with emotional disorders and behavioural problems was also found to be low (WHO, 2015a, 2015b). These quality appraisals also followed the GRADE assessment scheme. As such, it is possible that this type of behavioural, psychosocial interventions, presents a challenge that extends beyond the field of nature and health benefits in terms of generating research that is, within a medical, best-evidence paradigm, of high quality. Blinding and allocation concealment, for example, presents obvious challenges for behavioural-environmental interventions. However, attempts to blind participants and personnel from the specific research aims are possible, although rarely reported in the papers included in this review.

The principal quality of evidence factor according to the GRADE scheme concerns randomisation: RCTs are as a starting point rated as high-quality evidence and all other designs as low (Guyatt et al., 2008). While RCTs are commonly presumed to present the ideal source of data on the effects of interventions in prevention and medical sciences, we acknowledge that there are a number of criticisms of RCTs and that there is an emerging understanding of potentials in other types of designs (Frieden, 2017; Gottfredson et al., 2015). While well-designed and -conducted RCTs can have a strong internal validity, they sometimes lack external validity (Frieden, 2017). In other words, RCTs may be well suited for unbiased assessment of a specific causal phenomenon amongst a narrowly defined target group, but generalisability beyond the target group, the precise conditions under which the intervention is implemented and the study time span, is often limited. For prevention purposes, the usefulness of this research may be increased if supported and supplemented by large, high-quality cohort studies (Frieden, 2017). According to Frieden (2017), the internal validity may be increased in types of large-scale observational studies, much in the same way as is done in RCTs. Furthermore, while randomised group allocation is possible in many behavioural interventions, it may not be suited for or feasible in all contexts, for example, when the

subjects are schools or communities (Frieden, 2017; Gottfredson et al., 2015). Alternatively, regression discontinuity designs and comparison time series designs may provide unbiased estimates of intervention effects, where randomisation is not practical or possible (Gottfredson et al., 2015). Other types of quasi-experimental designs that maximise feasibility and acceptability for use in prevention research, which in turn increases ecological validity, includes dynamic wait-listed designs, stepped wedge or regression point displacement designs (Ting Fok et al., 2015; Wyman and Brown, 2015). We did not identify any such designs amongst the included studies.

As described in the methods section, we made minor adjustments to the GRADE scheme to increase the suitability to the research field. For example, we did not downgrade on the basis of blinding of participants or personnel involved in the intervention in a traditional sense, but only if participants or personnel were informed about the study aims and research questions. We acknowledge that this decreases the comparability of the assessments in relation to other systematic reviews. We maintain that the core strengths of GRADE, transparency and rigor, and the usefulness of assessing the quality of the evidence at an outcome level remains. While we have discussed factors at sample composition, situational and contextual levels, e.g. self-selection and characteristics of the individual nature-experiences, which could potentially reduce generalisability of the included studies, we did not systematically assess other features of external validity such as intervention or program facilitator competence or motivation. This might likewise reduce generalisability, although this type of variability is, similar to blinding of participants or personnel, not easily controlled for in the present type of research. In fact, facilitator characteristics may in some instances be seen as an integrated part of the nature-experience rather than a source of bias. Furthermore, this review was nested within a larger review that also included adults (Mygind et al., 2019). The comprehensiveness of the literature search might have elicited a high retrieval rate of relevant research through covering diverse fields of research and search terms. However, the

approach would be immensely time-consuming to reproduce which causes reduced replicability. Due to a scarcity of resources, only one investigator extracted data from the original studies which involves a risk of data extraction errors. Due to substantial collaboration and on-going discussion within the author team, which in practice meant that more than one investigator was familiar with most original studies, we do not believe that this involved a substantial risk.

Conclusion

In this systematic review, we summarised and evaluated the evidence for benefits of immersive nature-experience on children and adolescents' mental, physical and social health. We identified 84 publications that met the inclusion criteria. Conditional support for benefits of diverse immersive nature-experience was found for self-esteem, self-efficacy, resilience and academic and cognitive performance. Correlational research evidenced higher levels of physical activity in natural environments compared to comparison conditions. Benefits for outcomes such as self-concept, problem solving and mood were more inconclusive. In addition, social skill-oriented and behavioural indicators were improved, although the categories included different outcomes. Future research should strive towards using randomisation on an individual or cluster level when possible, or other types of designs, e.g. regression discontinuity designs or comparison time series designs. Randomised allocation used within a waitlist design may, for example, be a feasible and useful approach in many contexts. Finally, an increased detail of reporting about, and general attention to, group allocation generation, intervention and control group comparability (including sociodemographic information), blinding (participants, personnel and outcome assessors), recruitment and sampling would increase interpretability and quality of the research.

References

- American Institutes for Research, 2005. Effects of Outdoor Education Programs for Children in California. The California Department of Education, USA.
- Ang, R.P., Farihah, N., Lau, S., 2014. An outcome evaluation of the implementation of the Outward Bound Singapore five-day "intercept" program. *J. Adolesc.* 37, 771–778.
<https://doi.org/10.1016/j.adolescence.2014.05.003>
- Barton, J., Bragg, R., Pretty, J., Roberts, J., Wood, C., 2016. The Wilderness Expedition: An Effective Life Course Intervention to Improve Young People's Well-Being and Connectedness to Nature. *Journal of Experiential Education* 39, 59–72.
- Bentsen, P., Andkjær, S., Ejbye-Ernst, N., 2009a. *Friluftsliv: natur, samfund og pædagogik*. Munksgaard Danmark.

- Bentsen, P., Mygind, E., Randrup, T.B., 2009b. Towards an understanding of udeskole: education outside the classroom in a Danish context. *Education 3–13* 37, 29–44.
- Bettmann, J., Tucker, A., 2011. Shifts in Attachment Relationships: A Study of Adolescents in Wilderness Treatment. *Child & Youth Care Forum* 40, 499–519. <https://doi.org/10.1007/s10566-011-9146-6>
- Bettmann, J.E., Russell, K.C., Parry, K.J., 2013. How Substance Abuse Recovery Skills, Readiness to Change and Symptom Reduction Impact Change Processes in Wilderness Therapy Participants. *Journal of Child and Family Studies* 22, 1039–1050. <https://doi.org/10.1007/s10826-012-9665-2>
- Bowen, D.J., Neill, J.T., 2016. Effects of the PCYC Catalyst outdoor adventure intervention program on youths' life skills, mental health, and delinquent behaviour. *International Journal of Adolescence and Youth* 21, 34–55. <https://doi.org/10.1080/02673843.2015.1027716>
- Bowen, D.J., Neill, J.T., Crisp, S.J.R., 2016. Wilderness adventure therapy effects on the mental health of youth participants. *Evaluation and Program Planning* 58, 49–59. <https://doi.org/10.1016/j.evalprogplan.2016.05.005>
- Bowler, D.E., Buyung-Ali, L.M., Knight, T.M., Pullin, A.S., 2010. A systematic review of evidence for the added benefits to health of exposure to natural environments. *BMC public health* 10, 456.
- Bratman, G.N., Hamilton, J.P., Daily, G.C., 2012. The impacts of nature experience on human cognitive function and mental health: Nature experience, cognitive function, and mental health. *Annals of the New York Academy of Sciences* 1249, 118–136. <https://doi.org/10.1111/j.1749-6632.2011.06400.x>
- Brussoni, M., Gibbons, R., Gray, C., Ishikawa, T., Sandseter, E., Bienenstock, A., Chabot, G., Fuselli, P., Herrington, S., Janssen, I., Pickett, W., Power, M., Stanger, N., Sampson, M., Tremblay, M., 2015. What is the Relationship between Risky Outdoor Play and Health in Children? A Systematic Review. *International Journal of Environmental Research and Public Health* 12, 6423–6454. <https://doi.org/10.3390/ijerph120606423>
- Connelly, J., 2012. Adventure-Based Counseling and Self-Efficacy with High School Freshmen. ProQuest LLC.
- DeMille, S.M., 2015. Do therapeutic factors and client gender impact treatment outcomes for adolescents participating in outdoor behavioral healthcare treatment? Capella University.
- DeMille, S.M., Comart, C., Tucker, A., 2014. Body Composition Changes in an Outdoor Behavioral Healthcare Program. *Ecopsychology* 6, 174–182. <https://doi.org/10.1089/eco.2014.0012>
- Dettweiler, U., Becker, C., Auestad, B.H., Simon, P., Kirsch, P., 2017. Stress in School. Some Empirical Hints on the Circadian Cortisol Rhythm of Children in Outdoor and Indoor Classes. *International Journal of Environmental Research and Public Health* 14, 475. <https://doi.org/10.3390/ijerph14050475>
- Dibben, C., Playford, C., Mitchell, R., 2017. Be(ing) prepared: Guide and Scout participation, childhood social position and mental health at age 50—a prospective birth cohort study. *J Epidemiol Community Health* 71, 275–281. <https://doi.org/10.1136/jech-2016-207898>
- Ding, H., Hu, G.L., Zheng, X.Y., Chen, Q., Threapleton, D.E., Zhou, Z.H., 2015. The Method Quality of Cross-Over Studies Involved in Cochrane Systematic Reviews. *PLoS One* 10. <https://doi.org/10.1371/journal.pone.0120519>
- Duerden, M.D., Widmer, M.A., Taniguchi, S.T., McCoy, J.K., 2009. Adventures in Identity Development: The Impact of Adventure Recreation on Adolescent Identity Development. *Identity* 9, 341–359. <https://doi.org/10.1080/15283480903422806>

- Edwards, L.C., Bryant, A.S., Keegan, R.J., Morgan, K., Cooper, S.-M., Jones, A.M., 2018. "Measuring" Physical Literacy and Related Constructs: A Systematic Review of Empirical Findings. *Sports Med* 48, 659–682. <https://doi.org/10.1007/s40279-017-0817-9>
- Ee, J., Ong, C.W., 2014. Which social emotional competencies are enhanced at a social emotional learning camp? *Journal of Adventure Education and Outdoor Learning* 14, 24–41. <https://doi.org/10.1080/14729679.2012.761945>
- Engemann, K., Pedersen, C.B., Arge, L., Tsirogiannis, C., Mortensen, P.B., Svenning, J.-C., 2019. Residential green space in childhood is associated with lower risk of psychiatric disorders from adolescence into adulthood. *PNAS* 116, 5188–5193. <https://doi.org/10.1073/pnas.1807504116>
- Faber Taylor, A., Kuo, F.E., 2009. Children with attention deficits concentrate better after walk in the park. *Journal of attention disorders* 12, 402–409.
- Faber Taylor, A., Kuo, F.E., 2006. Is contact with nature important for healthy child development? State of the evidence, in: Spencer, C., Blades, M. (Eds.), *Children and Their Environments*. Cambridge University Press, Cambridge, UK, pp. 124–140.
- Ferraro, F.M., 2015. Enhancement of Convergent Creativity Following a Multiday Wilderness Experience. *Ecopsychology* 7, 7–11. <https://doi.org/10.1089/eco.2014.0043>
- Fjørtoft, I., 2004. Landscape as Playscape: The Effects of Natural Environments on Children's Play and Motor Development. *Children, Youth and Environments* 14, 21–44.
- Frieden, T.R., 2017. Evidence for Health Decision Making — Beyond Randomized, Controlled Trials. *New England Journal of Medicine* 377, 465–475. <https://doi.org/10.1056/NEJMr1614394>
- Fuller, C., Powell, D., Fox, S., 2017. Making gains: the impact of outdoor residential experiences on students' examination grades and self-efficacy. *Educational Review* 69, 232–247. <https://doi.org/10.1080/00131911.2016.1199538>
- Furman, N., Sibthorp, J., 2014. The Development of Prosocial Behavior in Adolescents: A Mixed Methods Study From NOLS. *Journal of Experiential Education* 37, 160–175. <https://doi.org/10.1177/1053825913489105>
- Gehris, J.S., 2007. A Quantitative and Qualitative Investigation of the Effects of Adventure Education on High School Students. Temple University.
- Gelter, H., 2000. Friluftsliv: The Scandinavian Philosophy of Outdoor Life. *Canadian Journal of Environmental Education (CJEE)* 5, 77–92.
- Gillespie, E., Allen-Craig, S., 2009. The enhancement of resilience via a wilderness therapy program: A preliminary investigation. *Journal of Outdoor and Environmental Education* 13, 39.
- Gottfredson, D.C., Cook, T.D., Gardner, F.E.M., Gorman-Smith, D., Howe, G.W., Sandler, I.N., Zafft, K.M., 2015. Standards of Evidence for Efficacy, Effectiveness, and Scale-up Research in Prevention Science: Next Generation. *Prev Sci* 16, 893–926. <https://doi.org/10.1007/s11121-015-0555-x>
- Greenhalgh, T., Peacock, R., 2005. Effectiveness and efficiency of search methods in systematic reviews of complex evidence: audit of primary sources. *BMJ* 331, 1064–1065. <https://doi.org/10.1136/bmj.38636.593461.68>
- Grønningsæter, I., Hallås, O., Kristiansen, T., Nævdal, F., 2007. Fysisk aktivitet hos 11 – 12-åringar i skulen. *Tidsskriftet Den Norske Legeforeng*.
- Guthrie, H., 2004. Adventure therapy for children with mental disorders: A treatment outcome study. The University of Akron, USA.
- Guyatt, G., Oxman, A.D., Akl, E.A., Kunz, R., Vist, G., Brozek, J., Norris, S., Falck-Ytter, Y., Glasziou, P., deBeer, H., Jaeschke, R., Rind, D., Meerpohl, J., Dahm, P., Schünemann, H.J.,

2011. GRADE guidelines: 1. Introduction—GRADE evidence profiles and summary of findings tables. *Journal of Clinical Epidemiology* 64, 383–394.
<https://doi.org/10.1016/j.jclinepi.2010.04.026>
- Guyatt, G.H., Oxman, A.D., Vist, G.E., Kunz, R., Falck-Ytter, Y., Alonso-Coello, P., Schünemann, H.J., 2008. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ (Clinical research ed.)*.
- Harper, N.J., Russell, K.C., Cooley, R., Cupples, J., 2007. Catherine Freer Wilderness Therapy Expeditions: An Exploratory Case Study of Adolescent Wilderness Therapy, Family Functioning, and the Maintenance of Change. *Child Youth Care Forum* 36, 111.
<https://doi.org/10.1007/s10566-007-9035-1>
- Hartig, T., Mitchell, R., Vries, S. de, Frumkin, H., 2014. Nature and Health. *Annual Review of Public Health* 35, 207–228. <https://doi.org/10.1146/annurev-publhealth-032013-182443>
- Hayhurst, J., Hunter, J.A., Kafka, S., Boyes, M., 2015. Enhancing resilience in youth through a 10-day developmental voyage. *Journal of Adventure Education and Outdoor Learning* 15, 40–52. <https://doi.org/10.1080/14729679.2013.843143>
- Herman, K.M., Craig, C.L., Gauvin, L., Katzmarzyk, P.T., 2009. Tracking of obesity and physical activity from childhood to adulthood: the Physical Activity Longitudinal Study. *Int J Pediatr Obes* 4, 281–288. <https://doi.org/10.3109/17477160802596171>
- Higgins, J.P.T., Altman, D.G., Gøtzsche, P.C., Jüni, P., Moher, D., Oxman, A.D., Savović, J., Schulz, K.F., Weeks, L., Sterne, J.A.C., 2011. The Cochrane Collaboration’s tool for assessing risk of bias in randomised trials. *BMJ* 343, d5928.
<https://doi.org/10.1136/bmj.d5928>
- Hinds, J., 2011. Woodland Adventure for Marginalized Adolescents: Environmental Attitudes, Identity and Competence. *Applied Environmental Education & Communication* 10, 228–237. <https://doi.org/10.1080/1533015X.2011.669689>
- Hohashi, N., Kobayashi, K., 2013. The effectiveness of a forest therapy (shinrin-yoku) program for girls aged 12 to 14 years: A crossover study. *Stress Science Research* 28, 82–89.
<https://doi.org/10.5058/stresskagakukenkyl.28.82>
- Holland, W.H., Powell, R.B., Thomsen, J.M., Monz, C.A., 2018. A Systematic Review of the Psychological, Social, and Educational Outcomes Associated With Participation in Wildland Recreational Activities. *Journal of Outdoor Recreation, Education, and Leadership* 10, 197–225. <http://dx.doi.org/10.18666/JOREL-2018-V10-I3-8382>
- Hunter, J.A., Hayhurst, J., Kafka, S., Boyes, M., Ruffman, T., O’Brien, K., Stringer, M., 2013. Elevated self-esteem 12 months following a 10-day developmental voyage: Elevated self-esteem. *Journal of Applied Social Psychology* 43, 1956–1961.
<https://doi.org/10.1111/jasp.12132>
- Hunter, J.A., Kafka, S., Hayhurst, J., Clark, H., Dickerson, D., Harold, G., Boyes, M., O’Brien, K., Stringer, M., 2010. Increased self-efficacy following a ten-day developmental voyage. *Journal of Child & Adolescent Mental Health* 22, 63–65.
<https://doi.org/10.2989/17280583.2010.496943>
- Jelalian, E., Lloyd-Richardson, E.E., Mehlenbeck, R.S., Hart, C.N., Flynn-O’Brien, K., Kaplan, J., Neill, M., Wing, R.R., 2010. Behavioral Weight Control Treatment with Supervised Exercise or Peer-Enhanced Adventure for Overweight Adolescents. *The Journal of Pediatrics* 157, 923–928.e1. <https://doi.org/10.1016/j.jpeds.2010.05.047>
- Jelalian, E., Mehlenbeck, R., Lloyd-Richardson, E.E., Birmaher, V., Wing, R.R., 2006. “Adventure therapy” combined with cognitive-behavioral treatment for overweight adolescents. *Int. J. Obes.* 30, 31–39. <https://doi.org/10.1038/sj.ijo.0803069>

- Jelalian, E., Sato, A., Hart, C.N., 2011. The effect of group-based weight-control intervention on adolescent psychosocial outcomes: Perceived peer rejection, social anxiety, and self-concept. *Children's Health Care* 40, 197–211. <https://doi.org/10.1080/02739615.2011.590391>
- Jones, C.D., Lowe, L.A., Risler, E.A., 2004. The Effectiveness of Wilderness Adventure Therapy Programs for Young People Involved in the Juvenile Justice System. *Residential Treatment For Children & Youth* 22, 53–67. https://doi.org/10.1300/J007v22n02_04
- Kafka, S., Hunter, J.A., Hayhurst, J., Boyes, M., Thomson, R.L., Clarke, H., Grocott, A.M., Stringer, M., O'Brien, K.S., 2012. A 10-day developmental voyage: converging evidence from three studies showing that self-esteem may be elevated and maintained without negative outcomes. *Social Psychology of Education* 15, 571–601. <https://doi.org/10.1007/s11218-012-9177-3>
- Kalisch, K.R., Bobilya, A.J., Daniel, B., 2011. The Outward Bound Solo: A Study of Participants' Perceptions. *Journal of Experiential Education* 34, 1–18. <https://doi.org/10.5193/JEE34.1.1>
- Klatte, M., Lachmann, T., Meis, M., others, 2010. Effects of noise and reverberation on speech perception and listening comprehension of children and adults in a classroom-like setting. *Noise and Health* 12, 270.
- Kuo, M., 2015. How might contact with nature promote human health? Promising mechanisms and a possible central pathway. *Front. Psychol.* 6. <https://doi.org/10.3389/fpsyg.2015.01093>
- Larson, B.A., 2007. Adventure camp programs, self-concept, and their effects on behavioral problem adolescents. *Journal of Experiential Education* 29, 313–330.
- Lenroot, R.K., Giedd, J.N., 2006. Brain development in children and adolescents: Insights from anatomical magnetic resonance imaging. *Neuroscience & Biobehavioral Reviews, Methodological and Conceptual Advances in the Study of Brain-Behavior Dynamics: A Multivariate Lifespan Perspective* 30, 718–729. <https://doi.org/10.1016/j.neubiorev.2006.06.001>
- Lokos, R.M., 2013. The impact of wilderness education programs on participant self-efficacy beliefs (Ed.D.). Seattle University, United States -- Washington.
- Lovell, R., 2009. Evaluation of physical activity at Forest School.
- Maller, C., Townsend, M., Pryor, A., Brown, P., St Leger, L., 2006. Healthy nature healthy people: 'contact with nature' as an upstream health promotion intervention for populations. *Health Promot Int* 21, 45–54. <https://doi.org/10.1093/heapro/dai032>
- Mann, M.J., 2007. THE INFLUENCE OF PROJECT CHALLENGE ON LEVELS OF PSYCHOSOCIAL DEVELOPMENT AND RESILIENCE IN ADOLESCENT GIRLS AT RISK FOR DELINQUENCY. University of Florida.
- Margalit, D., Ben-Ari, A., 2014. The Effect of Wilderness Therapy on Adolescents' Cognitive Autonomy and Self-efficacy: Results of a Non-randomized Trial. *Child and Youth Care Forum* 43, 181–194. <https://doi.org/10.1007/s10566-013-9234-x>
- McCurdy, L.E., Winterbottom, K.E., Mehta, S.S., Roberts, J.R., 2010. Using Nature and Outdoor Activity to Improve Children's Health. *Current Problems in Pediatric and Adolescent Health Care* 40, 102–117. <https://doi.org/10.1016/j.cppeds.2010.02.003>
- McGowan, A.L., 2016. Impact of One-Semester Outdoor Education Programs on Adolescent Perceptions of Self-Authorship. *Journal of Experiential Education* 39, 386–411. <https://doi.org/10.1177/1053825916668902>
- Mirkin, B.J., 2013. Examining social climate and youth social goals on extended wilderness courses: A path toward improving participant experiences. University of New Hampshire.

- Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G., The PRISMA Group, 2009. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Med* 6, e1000097. <https://doi.org/10.1371/journal.pmed.1000097>
- Mojtabai, R., Olfson, M., Han, B., 2016. National Trends in the Prevalence and Treatment of Depression in Adolescents and Young Adults. *Pediatrics* e20161878. <https://doi.org/10.1542/peds.2016-1878>
- Muñoz, S.-A., 2009. *Children in the Outdoors*. London: Sustainable Development Research Centre.
- Mutz, M., Müller, J., 2016. Mental health benefits of outdoor adventures: Results from two pilot studies. *Journal of Adolescence* 49, 105–114. <https://doi.org/10.1016/j.adolescence.2016.03.009>
- Mygind, E., 2016. Physical Activity during Learning Inside and Outside the Classroom. *Health Behavior and Policy Review* 3, 455–467. <https://doi.org/10.14485/HBPR.3.5.6>
- Mygind, E., 2009. A comparison of childrens' statements about social relations and teaching in the classroom and in the outdoor environment. *Journal of Adventure Education and Outdoor Learning* 9, 151–169. <https://doi.org/10.1080/14729670902860809>
- Mygind, E., 2007. A Comparison between Children's Physical Activity Levels at School and Learning in an Outdoor Environment. *Journal of Adventure Education and Outdoor Learning* 7, 161–176.
- Mygind, E., 2005. Elevudsagn om naturens rum og klasseværelset, in: *Udeundervisning i Folkeskolen: Et Casestudie Om En Naturklasse På Rødkilde Skole Og Virkningerne Af En Ugentlig Obligatorisk Naturdag På Yngste Klassestrin i Perioden 2000-2003*. Museum Tusculanum.
- Ng, M., Fleming, T., Robinson, M., Thomson, B., Graetz, N., Margono, C., Mullany, E.C., Biryukov, S., Abbafati, C., Abera, S.F., Abraham, J.P., Abu - Rmeileh, N.M.E., Achoki, T., Al - Buhairan, F.S., Alemu, Z.A., Alfonso, R., Ali, M.K., Ali, R., Guzman, N.A., Ammar, W., Anwari, P., Banerjee, A., Barquera, S., Basu, S., Bennett, D.A., Bhutta, Z., Blore, J., Cabral, N., Nonato, I.C., Chang, J.-C., Chowdhury, R., Courville, K.J., Criqui, M.H., Cundiff, D.K., Dabhadkar, K.C., Dandona, L., Davis, A., Dayama, A., Dharmaratne, S.D., Ding, E.L., Durrani, A.M., Esteghamati, A., Farzadfar, F., Fay, D.F.J., Feigin, V.L., Flaxman, A., Forouzanfar, M.H., Goto, A., Green, M.A., Gupta, R., Hafezi - Nejad, N., Hankey, G.J., Harewood, H.C., Havmoeller, R., Hay, S., Hernandez, L., Husseini, A., Idrisov, B.T., Ikeda, N., Islami, F., Jahangir, E., Jassal, S.K., Jee, S.H., Jeffreys, M., Jonas, J.B., Kabagambe, E.K., Khalifa, S.E.A.H., Kengne, N.P., Khader, Y.S., Khang, Y.-H., Kim, D., Kimokoti, R.W., Kinge, J.M., Kokubo, Y., Kosen, S., Kwan, G., Lai, T., Leinsalu, M., Li, Y., Liang, X., Liu, S., Logroscino, G., Lotufo, P.A., Lu, Y., Ma, J., Mainoo, N.K., Mensah, G.A., Merriman, T.R., Mokdad, A.H., Moschandreas, J., Naghavi, M., Naheed, A., Nand, D., Narayan, K.M.V., Nelson, E.L., Neuhausser, M.L., Nisar, M.I., Ohkubo, T., Oti, S.O., Pedroza, A., Prabhakaran, D., Roy, N., Sampson, U., Seo, H., Sepanlou, S.G., Sepanlou, S.G., Shiri, R., Shiue, I., Singh, G.M., Singh, J.A., Skirbekk, V., Stapelberg, N.J.C., Sturua, L., Sykes, B.L., Tobias, M., Tran, B.X., Trasande, L., Toyoshima, H., Vijver, S.V.D., Vasankari, T.J., Veerman, J.L., Velasquez - Melendez, G., Vlassov, V.V., Vollset, S.E., Vos, T., Wang, C., Wang, X., Weiderpass, E., Werdecker, A., Wright, J.L., Yang, Y.C., Yatsuya, H., Yoon, J., Yoon, S.-J., Zhao, Y., Zhou, M., Zhu, S., Lopez, A.D., Murray, C.J.L., Gakidou, E., 2014. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013.(Report)(Author abstract). *The Lancet* 384, 766–781. [https://doi.org/10.1016/S0140-6736\(14\)60460-8](https://doi.org/10.1016/S0140-6736(14)60460-8)

- Norton, C.L., 2007. Understanding the impact of wilderness therapy on adolescent depression and psychosocial development.
- Norton, C.L., Watt, T.T., 2014. Exploring the impact of a wilderness-based positive youth development program for urban youth. *Journal of Experiential Education* 37, 335–350.
- Nutbeam, D., 1998. Evaluating Health Promotion—Progress, Problems and solutions. *Health Promot Int* 13, 27–44. <https://doi.org/10.1093/heapro/13.1.27>
- O'Brien, K., Lomas, T., 2017. Developing a Growth Mindset through outdoor personal development: can an intervention underpinned by psychology increase the impact of an outdoor learning course for young people? *Journal of Adventure Education and Outdoor Learning* 17, 133–147. <https://doi.org/10.1080/14729679.2016.1232199>
- Orren, P.M., Werner, P.D., 2007. Effects of brief wilderness programs in relation to adolescents' race. *Journal of Experiential Education* 30, 117–133.
- O'Shea, K., 2008. Exploring the benefits of an outdoor adventure program for improving self-Esteem and self-Efficacy and reducing problem behaviors in adolescent girls.
- Polanczyk, G.V., Salum, G.A., Sugaya, L.S., Caye, A., Rohde, L.A., 2015. Annual Research Review: A meta-analysis of the worldwide prevalence of mental disorders in children and adolescents. *Journal of Child Psychology and Psychiatry* 56, 345–365. <https://doi.org/10.1111/jcpp.12381>
- Reed, K., Wood, C., Barton, J., Pretty, J.N., Cohen, D., Sandercock, G.R.H., 2013. A Repeated Measures Experiment of Green Exercise to Improve Self-Esteem in UK School Children. *PLoS ONE* 8, e69176. <https://doi.org/10.1371/journal.pone.0069176>
- Richmond, D.J., 2016. Developing noncognitive factors through outdoor adventure education: experiences that complement classroom learning: IR - Theses & Dissertations 3. University of Utah, USA.
- Ritchie, R., Ritchie, S.D., 2014. Promoting resilience and wellbeing through an outdoor intervention designed for Aboriginal adolescents. *Rural and remote health* 14, 2523.
- Roe, J., Aspinall, P., 2011. The restorative outcomes of forest school and conventional school in young people with good and poor behaviour. *Urban Forestry & Urban Greening* 10, 205–212. <https://doi.org/10.1016/j.ufug.2011.03.003>
- Romi, S., Kohan, E., 2004. Wilderness Programs: Principles, Possibilities and Opportunities for Intervention with Dropout Adolescents. *Child & Youth Care Forum* 33, 115–136. <https://doi.org/10.1023/B:CCAR.0000019634.47226.ab>
- Russell, K.C., 2006. Evaluating the Effects of the Wendigo Lake Expedition Program on Young Offenders. *Youth Violence and Juvenile Justice* 4, 185–203. <https://doi.org/10.1177/1541204006286317>
- Ryan, R., Hill, S., Broclain, D., Oliver, S., Pictor, M., Cochrane Consumers and Communication Review Group, 2013. Study Design Guide.
- Sandell, K., 2004. Friluftslivets värden. En internationell forskningsutblick. Arbetsrapport 20.
- Schantz, P., Silvander, U., 2004. Forskning och utbildning inom friluftsliv: Utredning och förslag. Frisam/Svenskt Friluftsliv.
- Schutte, A.R., Torquati, J.C., Beattie, H.L., 2017. Impact of Urban Nature on Executive Functioning in Early and Middle Childhood. *Environment and Behavior* 49, 3–30. <https://doi.org/10.1177/0013916515603095>
- Shonkoff, J.P., Boyce, W.T., McEwen, B.S., 2009. Neuroscience, Molecular Biology, and the Childhood Roots of Health Disparities: Building a New Framework for Health Promotion and Disease Prevention. *JAMA* 301, 2252–2259. <https://doi.org/10.1001/jama.2009.754>
- Sibthorp, J., Furman, N.N., Paisley, K., Gookin, J., 2008. Long-term impacts of wilderness education: Preliminary findings from NOLS. *Research in Outdoor Education* 9, 86–102.

- Sproule, J., Martindale, R., Wang, J., Allison, P., Nash, C., Gray, S., 2013. Investigating the experience of outdoor and adventurous project work in an educational setting using a self-determination framework. *European Physical Education Review* 19, 315–328. <https://doi.org/10.1177/1356336X13495629>
- Taylor, S.E., 2010. Mechanisms linking early life stress to adult health outcomes. *PNAS* 107, 8507–8512. <https://doi.org/10.1073/pnas.1003890107>
- Telama, R., 2009. Tracking of physical activity from childhood to adulthood: a review. *Obes Facts* 2, 187–195. <https://doi.org/10.1159/000222244>
- Tillmann, S., Tobin, D., Avison, W., Gilliland, J., 2018. Mental health benefits of interactions with nature in children and teenagers: a systematic review. *J Epidemiol Community Health jech-2018-210436*. <https://doi.org/10.1136/jech-2018-210436>
- Ting Fok, C.C., Henry, D., Allen, J., 2015. Research Designs for Intervention Research with Small Samples II: Stepped Wedge and Interrupted Time-Series Designs. *Prev Sci* 16, 967–977. <https://doi.org/10.1007/s11121-015-0569-4>
- Tucker, A., Norton, C.L., DeMille, S.M., Hobson, J., 2016. The Impact of Wilderness Therapy. *Journal of Experiential Education* 39, 15–30. <https://doi.org/10.1177/1053825915607536>
- Twohig-Bennett, C., Jones, A., 2018. The health benefits of the great outdoors: A systematic review and meta-analysis of greenspace exposure and health outcomes. *Environmental Research* 166, 628–637. <https://doi.org/10.1016/j.envres.2018.06.030>
- Vallet, C., André, N., Gentet, J.-C., Verschuur, A., Michel, G., Sotteau, F., Martha, C., Grélot, L., 2015. Pilot evaluation of physical and psychological effects of a physical trek programme including a dog sledding expedition in children and teenagers with cancer. *ecancermedicalsecience* 9. <https://doi.org/10.3332/ecancer.2015.558>
- van den Berg, A.E., van den Berg, C.G., 2011. A comparison of children with ADHD in a natural and built setting: Nature and ADHD. *Child: Care, Health and Development* 37, 430–439. <https://doi.org/10.1111/j.1365-2214.2010.01172.x>
- Veitch, J., Salmon, J., Ball, K., 2007. Children's perceptions of the use of public open spaces for active free-play. *Children's geographies* 5, 409–422.
- Vigsø, B., Nielsen, V., 2006. *Børn og Udeliv*. CVU Vest Press, Danmark.
- Vissell, R., 2004. Effects of wilderness therapy on youth at risk's concept of self and *other: A deeper understanding of the journey (Ph.D.). Institute of Transpersonal Psychology, United States -- California.
- Vos, T., Barber, R., Bell, B., Bertozzi-Villa, A., Biryukov, S., Bolliger, I., Charlson, F., Davis, A., Degenhardt, L., Dicker, D., Duan, L., Erskine, H., Feigin, V., Ferrari, A., Fitzmaurice, C., Fleming, T., Graetz, N., Guinovart, C., Haagsma, J., Hansen, G., Hanson, S., Heuton, K., Higashi, H., Kassebaum, N., Kyu, H., Laurie, E., Liang, X., Lofgren, K., Lozano, R., Macintyre, M., Moradi-Lakeh, M., Naghavi, M., Nguyen, G., Odell, S., Ortblad, K., Roberts, D., Roth, G., Sandar, L., Serina, P., Stanaway, J., Steiner, C., Thomas, B., Vollset, S., Whiteford, H., Wolock, T., Ye, P., Zhou, M., Avila, M., Aasvang, G., Abbafati, C., Vos, T., 2015. Global, regional, and national incidence, prevalence, and years lived with disability for 301 acute and chronic diseases and injuries in 188 countries, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet (London, England)* 386, 743–800. [https://doi.org/10.1016/S0140-6736\(15\)60692-4](https://doi.org/10.1016/S0140-6736(15)60692-4)
- Walsh, M.A., 2009. Wilderness adventure programming as an intervention for youthful offenders: Self-efficacy, resilience, and hope for the future (Ph.D.). University of Minnesota, United States -- Minnesota.
- Wang, C.J., Woon-Chia, L., Kahlid, A., 2006. Effects of a five-day Outward Bound course on female students in Singapore. *Journal of Outdoor and Environmental Education* 10, 20.

- White, R., 2012a. A Sociocultural Investigation of the Efficacy of Outdoor Education to Improve Learner Engagement. *Emotional & Behavioural Difficulties* 17, 13–23. <https://doi.org/10.1080/13632752.2012.652422>
- White, R., 2012b. A sociocultural investigation of the efficacy of outdoor education to improve learner engagement. *Emotional and Behavioural Difficulties* 17, 13–23. <https://doi.org/10.1080/13632752.2012.652422>
- WHO, 2015a. Psychosocial interventions, treatment of emotional disorders. mhGAP Evidence Resource Centre, World Health Organization.
- WHO, 2015b. Psychosocial interventions for treatment of behavioural disorders. mhGAP Evidence Resource Centre, World Health Organization.
- Wood, C., Sandercock, G., Barton, J., 2014. Interactions between physical activity and the environment to improve adolescent self-esteem: A randomised controlled trial. *International Journal of Environment and Health* 7, 144–155. <https://doi.org/DOI:10.1504/IJENVH.2014.067359>
- Wyman, P.A., Brown, C.H., 2015. Designs for testing group-based interventions with limited numbers of social units: The dynamic wait-listed and regression point displacement designs. *Prev Sci* 16, 956–966. <https://doi.org/10.1007/s11121-014-0535-6>
- Yarwood, R., Tyrrell, N., 2012. Why children's geographies? *Geography* 97.
- Zachor, D.A., Vardi, S., Baron-Eitan, S., Brodai-Meir, I., Ginossar, N., Ben-Itzhak, E., 2017a. The effectiveness of an outdoor adventure programme for young children with autism spectrum disorder: a controlled study. *Dev Med Child Neurol* 59, 550–556. <https://doi.org/10.1111/dmcn.13337>