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Effectiveness of online tailored advice to prevent running-related injuries and promote preventive behaviour in Dutch trail runners: a pragmatic randomised controlled trial

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ABSTRACT

Background Trail running is popular worldwide, but there is no preventive intervention for running-related injury (RRI).

Aim To evaluate the effectiveness of adding online tailored advice (*TrailS*$_6$) to general advice on (1) the prevention of RRIs and (2) the determinants and actual preventive behaviour in Dutch trail runners.

Methods Two-arm randomised controlled trial over 6 months. 232 trail runners were randomly assigned to an intervention or control group. All participants received online general advice on RRI prevention 1 week after baseline. Every 2 weeks, participants in the intervention group received specific advice tailored to their RRI status. The control group received no further intervention. Bayesian mixed models were used to analyse the data.

Results Trail runners in the intervention group sustained 13% fewer RRIs compared with those in the control group after 6 months of follow-up (absolute risk difference −13.1%, 95% Bayesian highest posterior credible interval (95% BCI) −23.3 to −3.1). A preventive benefit was observed in one out of eight trail runners who had received the online tailored advice for 6 months (number needed to treat 8, 95% BCI 3 to 22). No significant between-group difference was observed on the determinants and actual preventive behaviours.

Conclusions Online tailored advice prevented RRIs among Dutch trail runners. Therefore, online tailored advice may be used as a preventive component in multicomponent RRI prevention programmes. No effect was observed on determinants and actual preventive behaviours.

Trial registration number The Netherlands National Trial Register (NTR5431).

INTRODUCTION

The world pandemic of physical inactivity is worrisome, and the reduction of its prevalence and burden is considered a public health priority.[1–3] Running is a very popular mode of physical activity worldwide.[4 5] Its related health benefits are well described in the literature,[6–8] and there is evidence suggesting that implementing running as a means of promoting physical activity is cost-effective.[9 10] According to VeiligheidNL (the Dutch Consumer Safety Institute), running was the third most practised sport in the Netherlands in 2013, with around 2.1 million people.[5] A mode of running known as trail running is quickly gaining in popularity.[11] Trail running consists of running in the outdoors, mainly on unpaved, rugged, muddy and/or hilly/mountain terrains.[11] To illustrate the spike in popularity, according to MudSweatTrails (the largest trail running community in the Netherlands), there was no trail running event in the Netherlands and Belgium in 2010, and there were over 150 in 2015.

Nonetheless, the risk of running-related injuries (RRIs) is a matter of concern because RRIs may lower the motivation to run and RRIs can also reach severity levels that might lead to dropping out of running practice.[11 12] This counteracts efforts to increase physical activity levels.[3] The prevalence proportion of RRIs in Dutch trail runners is estimated at 22.4% (95% frequentist confidence interval (CI) 20.9 to 24.0), and the injury rate is 10.7 RRIs per 1000 hours of running (95% CI 9.4 to 12.1).[11] Despite the burden of RRIs to the runners and for society,[11–13] there is no substantial evidence on interventions to prevent RRIs.[14–17] This is worrisome because RRI is an avoidable side effect of running, and therefore, preventive efforts are warranted.

Tailored online interventions are promising in promoting preventive behaviour in runners.[18] They are attractive due to their convenience, availability, interactivity, relative low cost to develop and implement and their ability to reach a large number of people.[18 19] There are no randomised controlled trials aimed at investigating the effectiveness of online tailored interventions on the prevention of RRIs, and the effects of such interventions on the determinants and actual preventive behaviour in periods longer than 3 months have never been described.[18] In addition, there is no evidence on interventions to prevent RRIs in trail runners. Therefore, the purpose of this study was to evaluate the effectiveness of adding online tailored advice to general advice on the determinants and actual preventive behaviour and on the prevention of RRIs in Dutch trail runners.

METHODS

Study design

This study was a two-arm pragmatic[20] randomised controlled trial over 6 months with blind assessment and blind delivery of intervention. The inclusion of individuals in the study was performed electronically, based on the eligibility criteria procedure implemented in the baseline questionnaire. This procedure ensured that the allocation of the participants in the intervention and control groups was

concealed. After the inclusion, all participants were randomly assigned to the intervention or control group according to a computer-generated simple randomisation scheme. The assessment and the delivery of the intervention were blinded as all data were collected via an online questionnaire, and the intervention was delivered online through the website of the project, ensuring no influence or bias of healthcare providers or assessors of outcomes. This study was approved by the medical ethics committee of the VU University Medical Center Amsterdam and has been prospectively registered in the Netherlands National Trial Register (NTR5431).

Sample size

The sample size was estimated based on calculations for longitudinal studies with repeated measurements.[21] The difference in change from baseline for warming up found in a previous study (13% in the intervention and 4% in the control group) investigating the effects of an online tailored intervention in runners was used as a reference effect size for preventive behaviours.[18] The reference value for the mean proportion of trail runners sustaining RRIs (22.4%) was based on a previous prospective cohort study conducted with the same source population.[11] The hypothesised reduction in the proportion of trail runners sustaining RRIs was 20% in the intervention and 10% in the control group, on average. Considering an α of 0.05, power of 0.8, three repeated measurements for preventive behaviours (at baseline and at 2 and 6 months after baseline), 13 repeated measurements for RRI (every 2 weeks during 6 months), a within-person correlation of 0.3[11] and a response rate of 70%,[11 12] the sample size was estimated at 105 participants for each group for preventive behaviours (total of 210 participants) and 92 participants for each group for RRI (total of 184 participants).

Participants

This study was composed of a sample of Dutch trail runners registered in the MudSweatTrails database (http://www.mudsweattrails.nl). In order to assure that the participants were active in trail running, all participants of a recent trail running event organised by MudSweatTrails at the time of the recruitment (ie, '*Salomon Koning van Spanje Trail*' held in May 2015) were invited to participate (n=1327). This trail is a traditional Dutch event that covers eight trail running races with distances varying from 15 to 62 km. In addition, the participants of a previous observational study conducted with the same source population were also invited to participate (n=185).[11] Individuals who agreed to participate through online informed consent, aged 18 years or over, involved in trail running and who completed the baseline questionnaire were eligible to participate.

Development of the intervention

The five steps of the Knowledge Transfer Scheme (KTS)[22] were followed in order to develop an intervention aimed at preventing RRIs in trail runners (table 1). The KTS process resulted in an evidence-based and practice-based online intervention, tailoring advice towards RRI prevention taking into account the RRI profile provided by the Oslo Sports Trauma Research Centre (OSTRC) Questionnaire on Health Problems.[23] The online tailored intervention was named *TrailS*$_6$ (online supplementary material appendix S1).

Intervention group

One week after baseline, all participants received a general advice towards RRIs prevention. During the follow-up, tailored advice was delivered based on the RRI classification generated by the OSTRC questionnaire, that is, (1) no RRI, (2) non-substantial RRI or (3) substantial RRI (defined as RRIs resulting in moderate or major reductions in training volume, moderate or major reductions in running performance or complete inability to run).[11 12 23] Participants who reported no RRI received advice aimed at maintaining their uninjured status (ie, primary prevention[24]). Participants who reported non-substantial RRIs received tailored advice aimed at promoting a fast recovery and to prevent the non-substantial RRI to become a substantial RRI (ie, secondary prevention[24]). Participants who reported substantial RRIs received tailored advice in order to prevent further consequences (ie, long-term burden and prolonged absence from running), permanent damage due to RRIs and subsequent RRIs (ie, tertiary prevention[24]).

The advice was instantaneously and automatically delivered after the completion of the RRI questionnaire by directing the participant to a web page hosted by the study website. This procedure was repeated every 2 weeks in order to monitor the RRI status and to adapt the tailored advice accordingly. Adherence to the intervention was assessed asking the participants which components of the tailored advice received in the last 2-week period they used.[25]

Table 1 Steps of the KTS followed in order to develop the *TrailS*$_6$ intervention

Steps of KTS	Description of performed activities
Step 1: problem statement	A prospective cohort study[11] was conducted with the same source population of the current trial in order to investigate the burden of RRIs in Dutch trail runners.
Step 2: evidence description	A summary of the available scientific evidence on RRIs, mainly with published systematic reviews,[17 46–48] was conducted, and this evidence was compiled with the results of the cohort study that was part of step 1 that investigated the burden of RRIs in Dutch trail runners.[11]
Step 3: KTG	A KTG was composed of five participants: ► One researcher in the field of sports injury prevention, who was also the chair of the KTG ► Two trail runners ► One healthcare professional, who is also a researcher in the field of RRIs ► One stakeholder (head of MudSweatTrails)
Step 4: product development	The KTG had one face-to-face meeting in order to discuss the cumulative evidence-based information generated in steps 1 and 2 and to propose an intervention aimed at preventing RRIs in trail runners. Further discussions with the participants of the KTG were carried out in order to revise the intervention materials and to adapt them to the needs, preferences and reality of trail runners (ie, evidence–practice-based intervention). This process resulted in an online tailored advice intervention (*TrailS*$_6$).
Step 5: evaluation	The evaluation of the intervention (*TrailS*$_6$) was conducted with the current randomised controlled trial.

MudSweatTrails: http://www.mudsweattrails.nl.
KTG, knowledge transfer group; KTS, Knowledge Transfer Scheme; RRI, running-related injury.

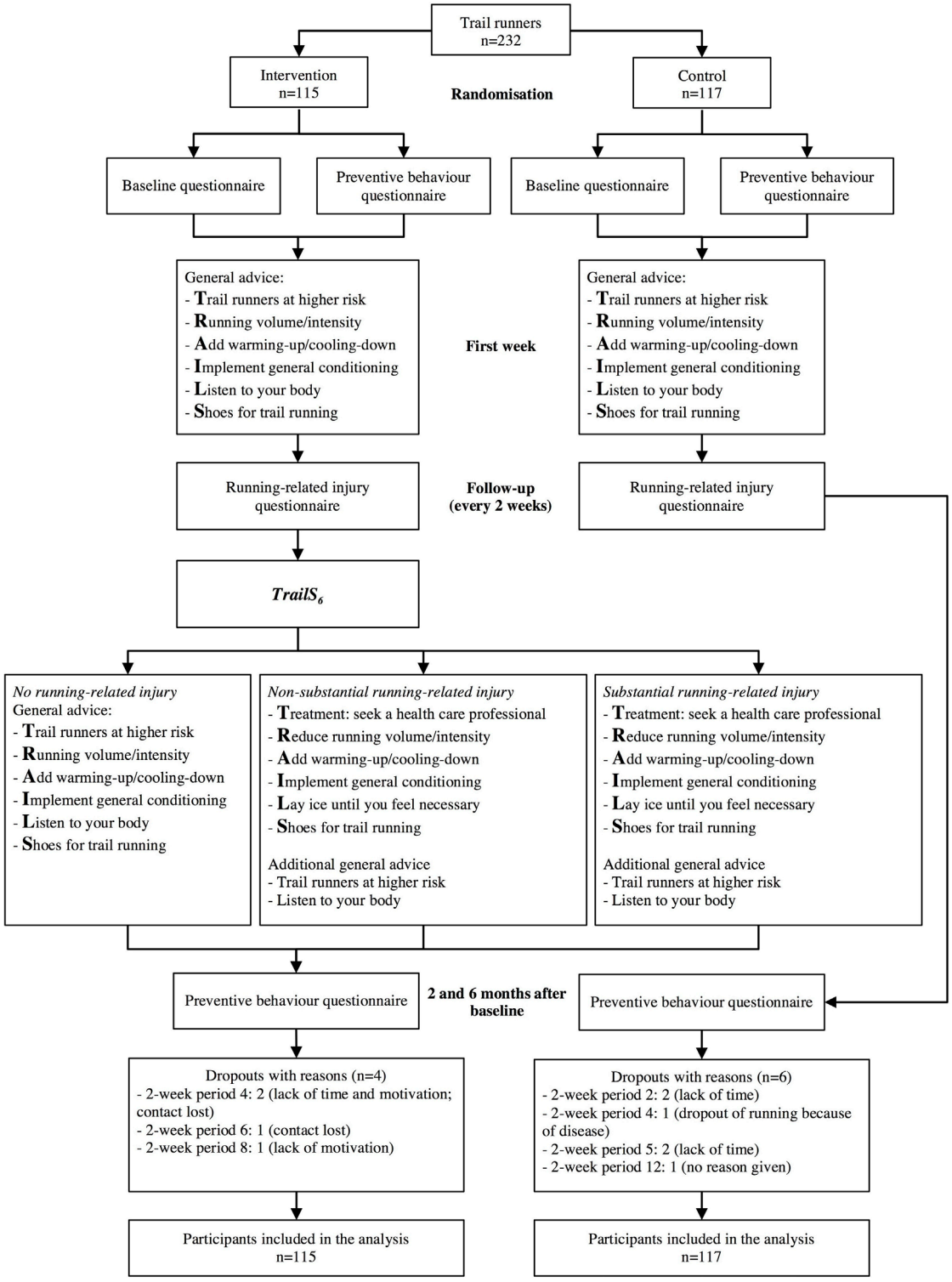

Figure 1 Design and flow of participants during the study.

Control group

The participants assigned to the control group received a general advice towards RRIs prevention 1 week after baseline. This advice was equal and in the same form as received by the intervention group at this stage. The control group did not receive any further advice during the follow-up (figure 1). The general advice delivered to the control group only once (ie, 1 week after baseline) may be considered 'usual care'[26] because these are the pieces of advice that the trail runners usually receive from trainers, healthcare professionals, friends, online sources, and so on, without a systematic and prospective tailoring and/or reminder.

Baseline questionnaire

After giving informed consent, a secured link to an online baseline questionnaire was sent by email to the participants. This questionnaire asked about demographics, education level,

running experience, trail running experience, history of RRIs (last 12 months) and current RRIs.

Preventive behavioural questionnaire

The Theory of Planned Behaviour was used as the conceptual model of behaviour in this study.[27 28] The determinants of performing the intervention and the behaviours towards RRI prevention were assessed at baseline, 2 months after baseline and at the end of the follow-up (online supplementary material appendix S2).

Preventive behaviour was assessed by a multiple-choice question. Five-point Likert scales were used to assess the determinants of performing the intervention. A single item was used to assess intention and subjective norm. Attitude was assessed by three items, and the average was used in the analysis.[29] Perceived behavioural control was assessed by two items and the average was used in the analysis.[29 30]

RRI questionnaire

A secured link to an online RRI questionnaire was sent by email every 2 weeks. The aims of this questionnaire were to collect information on running exposure and any complaint experienced in the preceding 2 weeks and to deliver the online tailored advice based on the RRI classification generated by the translated Dutch version of the OSTRC questionnaire.[23 31] RRI was defined as any disorder of the musculoskeletal (eg, muscles, tendons, ligaments, nerves and bones) or integumentary (eg, blisters and nail injuries) systems, or concussions experienced or sustained by an individual during participation in running. A recurrent RRI was defined as an RRI at the same location and of the same type of the index RRI, even if it concerned reinjuries (after full recovery) or exacerbations (no full recovery).[11 12 32] One investigator, who is also a physiotherapist (LCH), evaluated each self-reported complaint case by case. When the description of the complaint reported by the participant matched the RRI definition, the investigator classified the complaint as an RRI. The RRI registration and classification were performed according to previous studies on RRIs that used the OSTRC questionnaire, and the methods used can be found elsewhere.[11 12]

Data analysis

All analyses were performed in R 3.3.2 (R Foundation for Statistical Computing, Vienna, Austria) and followed the intention-to-treat principle. Descriptive analyses were performed to summarise the baseline data. Follow-up data were summarised using Bayesian linear mixed models (BLMMs) and Bayesian linear probability mixed models (BLPMMs)[33] in order to account for repeated measurements. The injury rate was estimated using Bayesian inference,[34] and the results were expressed as the number of RRIs per 1000 hours of running and its 95% Bayesian highest posterior density credible interval (95% BCI).

The main outcomes of this study were (1) the determinants of performing the intervention (intention, attitude, subjective norm and perceived behavioural control) as continuous variables, (2) preventive behaviours (online supplementary material appendix S2) as binary outcomes and (3) RRI as a binary outcome (ie, '0'=no RRI; '1'=RRI).

The effects of the intervention on the main outcomes were analysed as follows: (1) the determinants of performing the intervention were analysed using BLMM, (2) preventive behaviours were analysed using BLPMM and (3) the prevention of RRIs was analysed using BLPMM. Group, time and the interaction term composed of group and time were used as independent variables. Non-informative priors were used for the fixed[35] and random effects.[36] Calculations were based on sampling from the posterior distribution using the No-U-Turn Sampler[37] with five chains, 20 000 interactions, and leaving out the 5000 initial interactions of each chain.

The Bayes factor (BF) was estimated by calculating the posterior probability of a preventive effect, divided by the posterior probability of no preventive effect.[38] Preventive effects were defined as mean differences >0 for the BLMM models on determinants of performing the intervention, absolute risk differences (ARDs) >0 for the BLPMM models on preventive behaviours and ARD <0 for the BLPMM model on the prevention of RRIs. The strength of evidence favouring a preventive effect was classified as 'barely worth mentioning' (BF≤3), 'positive' (3<BF≤20), 'strong' (20<BF≤150) or 'very strong' (BF>150).[38] The results were considered significant when the 95% BCI did not contain the null effect and when the BF >3 (ie, substantial evidence supporting the preventive effect in favour of the intervention group).[39] The number needed to treat (NNT) was estimated by Bayesian inference for the significant results.[40]

Table 2 Baseline characteristics of the participants (n=232)

Characteristics	Intervention, n=115	Control, n=117
Age, mean (SD)	44.3 (9.8)	44.8 (9.3)
Gender, % (n)		
Male	68.7 (79)	66.7 (78)
Female	31.3 (36)	33.3 (39)
Height, mean (SD)	178.0 (8.2)	178.4 (9.0)
Weight, mean (SD)	72.3 (10.0)	72.9 (12.4)
BMI, mean (SD)	22.8 (2.1)	22.8 (2.5)
Running experience, median (IQR)	10.0 (5.0–21.5)	7.0 (5.0–17.0)
Trail running experience, median (IQR)	2.0 (1.5–4.0)	3.0 (2.0–4.0)
Education, % (n)		
Primary	2.6 (3)	1.7 (2)
Secondary	64.3 (74)	72.6 (85)
Tertiary	33.0 (38)	25.6 (30)
Current RRI, % (n)	29.6 (34)	21.4 (25)
Previous RRI, % (n)	41.7 (48)	41.0 (48)

SD, standard deviation; IQR, 25%–75% IQR; BMI, body mass index; RRI, running-related injury.

RESULTS

Flow of participants, running exposure and RRI characteristics

From the 1512 trail runners who were invited to participate, 232 (15.3%) responded and were included in the study. The baseline results are summarised in table 2. The flow of participants can be found in figure 1. During the follow-up, 10 participants (four in the intervention and six in the control group) dropped out of the study. However, the data collected of these participants until the time they dropped out were included in the analysis. The median of the response rate during the follow-up was 78.6% (25% to 75% interquartile range (IQR) 74.8–85.2) for the intervention group and 83.9% (IQR 74.1–89.3) for the control group.

A summary of the average running exposure and RRI characteristics can be found in table 3. A total of 87 participants (75.7%) reported 135 RRIs in the intervention group, and 91 (77.8%) reported 151 RRIs in the control group. Most RRIs were overuse injuries, either for the intervention (74.1%, n=100) or the control group (74.2%, n=112). A breakdown list with all RRIs reported per group can be found in the online supplementary material appendix S3.

Table 3 Running exposure and running-related injury characteristics

Characteristics	Intervention, n=115	Control, n=117
Running exposure		
Duration (hours/week)*	3.3 (3.0 to 3.6)	3.4 (3.0 to 3.9)
Frequency (times/week)*	2.5 (2.3 to 2.7)	2.5 (2.3 to 2.7)
Distance (km/week)*	30.1 (27.1 to 33.1)	30.7 (27.2 to 34.2)
Participation in events (per 2-week period)†	37.3% (32.1 to 42.3)	33.1% (28.7 to 37.4)
RRI characteristics		
Number of RRIs	135	151
Injury rate‡	18.0 (15.1 to 21.1)	18.8 (15.8 to 21.8)
Participants with RRIs†	39.4% (33.0 to 45.7)	36.5% (30.1 to 42.7)
Severity score*	39.0 (34.7 to 42.9)	36.6 (32.6 to 40.6)
Time loss (days/week)*	1.5 (1.1 to 1.8)	1.3 (1.0 to 1.6)
Duration (weeks)*	6.7 (5.7 to 7.7)	5.8 (4.8 to 6.7)

*The results are expressed as the mean over time and its 95% highest posterior density credible interval obtained by Bayesian linear mixed models.
†The results are expressed as the average percentage over time and its 95% highest posterior density credible interval obtained by Bayesian linear probability mixed models.
‡The injury rate is expressed as the number of RRIs per 1000 hours of running and its 95% highest posterior density credible interval obtained by Bayesian inference.
RRI, running-related injury.

Effects of the intervention on determinants of behaviour

The intervention presented a trend in decreasing the level of intention, attitude, subjective norm and perceived behavioural control towards performing the intervention after 2 and 6 months of follow-up, although the 95% BCI contained the null effect and the BFs suggested 'barely worth mentioning' preventive effects (table 4). Therefore, the effects on the determinants of performing the intervention are considered non-significant.

Effects of the intervention on preventive behaviours

The intervention presented a trend in increasing the probability of performing three out of seven preventive behaviours included in the intervention (warming up, cooling down and the use of specialised trail running shoes) after 2 and 6 months of follow-up, although the 95% BCI contained the null effect (table 4). Therefore, the effects of the intervention on preventive behaviours are considered non-significant.

Preventive effects of the intervention on RRIs

There was a 'very strong' evidence (BF 194.3) supporting a preventive effect on RRIs after 2 and 6 months of follow-up (table 4). Also, the 95% BCI for the ARD estimates did not contain the null effect. Therefore, the preventive effect of the online tailored advice on RRIs was significant. The NNT after 2 and 6 months of follow-up was 30 (95% BCI 14 to 87) and 8 (95% BCI 3 to 22), respectively.

Adherence to the intervention

The results regarding the adherence of the intervention group to the online tailored advice can be found in table 5. The adherence to at least one advice and to the 'longer recovery period' advice was higher for those reporting substantial RRIs than for those reporting no RRI. The percentage of participants taking no advice was lower for the participants reporting substantial RRIs than for those reporting no RRI. The 'reduction of running exposure' advice presented a lower adherence for those reporting no RRI than for those reporting non-substantial and substantial RRIs. The adherence to the 'medical attention' advice was higher for those reporting substantial RRIs than for those reporting non-substantial RRIs.

DISCUSSION

Effectiveness of the intervention on determinants and actual preventive behaviour

The evidence supporting a change on the determinants of performing the intervention and on promoting preventive behaviours towards RRI prevention was considered non-significant after 2 and 6 months of follow-up. A recent study found a statistically significant effect after 3 months of follow-up of an online tailored intervention on determinants (intention, attitude and risk perception) and on actual preventive behaviour (ie, warming up before training, before competitions and performing a proper workout regimen) in Dutch runners.[18] These conflicting results may be explained by differences in the content (eg, informative videos) and in the delivery of the intervention (eg, exposure to the intervention of 30 min) evaluated in the study of Adriaensens *et al*.[18] Also, the delivery of general advice to the control group at the beginning of the current study could have suppressed the effects of the intervention on preventive behaviours.

Effectiveness of the intervention on RRIs

In contrast to no effect on preventive behaviour, online tailored advice was effective for the prevention of RRIs after 6 months of follow-up. The mechanism of the preventive effect of the online tailored advice on the prevention of RRIs cannot be certainly determined in a behavioural perspective, while the intervention was not effective in changing preventive behaviour. Maybe 6 months of implementation of online tailored advice was too short to yield effects on individual preventive behaviours. Nonetheless, the small and/or non-significant effects on several preventive behaviours combined (eg, warming up, cooling down and the use of specialised trail running shoes) could have resulted in the significant preventive effect on RRIs.

Strengths and limitations of this study

This was the first study to investigate the effects of an online intervention to prevent RRIs. The allocation of the participants to the intervention and control groups was concealed, reducing the risk of selection bias.[41] The assessment of the outcomes and the delivery of the intervention were blinded, reducing the risk of detection bias.[41] Reducing the risk of bias increases the internal validity of the results.[42] The adherence of each

Table 4 Effectiveness of the online tailored advice (*TrailS*$_6$)

	Estimates at each time point						Within-group effect				Between-group effect		
	First measurement		2 months		6 months		After 2 months		After 6 months		After 2 months	After 6 months	
Outcomes	Intervention mean (95% BCI)	Control mean (95% BCI)	Intervention mean (95% BCI)	Control mean (95% BCI)	Intervention mean (95% BCI)	Control mean (95% BCI)	Intervention ES (95% BCI)	Control ES (95% BCI)	Intervention ES (95% BCI)	Control ES (95% BCI)	ES (95% BCI)	ES (95% BCI)	BF
Determinants of performing the intervention*													
Intention	1.29 (1.14 to 1.45)	1.20 (1.05 to 1.35)	1.19 (1.05 to 1.33)	1.22 (1.08 to 1.35)	1.09 (0.90 to 1.26)	1.23 (1.05 to 1.41)	−0.10 (−0.20 to −0.01)†	0.02 (−0.08 to 0.11)	−0.21 (−0.40 to −0.02)†	0.03 (−0.16 to 0.22)	−0.12 (−0.26 to 0.01)	−0.24 (−0.52 to 0.03)	0.0
Attitude	1.28 (1.18 to 1.39)	1.17 (1.06 to 1.27)	1.26 (1.17 to 1.36)	1.23 (1.13 to 1.32)	1.25 (1.13 to 1.37)	1.29 (1.17 to 1.41)	−0.02 (−0.07 to 0.04)	0.06 (0.00 to 0.12)†	−0.03 (−0.15 to 0.09)	0.12 (0.01 to 0.24)†	−0.08 (−0.16 to 0.01)	−0.16 (−0.32 to 0.01)	0.0
Subjective norm	0.52 (0.33 to 0.72)	0.45 (0.25 to 0.65)	0.58 (0.41 to 0.76)	0.57 (0.40 to 0.74)	0.65 (0.42 to 0.88)	0.69 (0.46 to 0.92)	0.06 (−0.06 to 0.18)	0.12 (0.00 to 0.24)	0.12 (−0.12 to 0.37)	0.24 (−0.01 to 0.48)	−0.06 (−0.23 to 0.11)	−0.12 (−0.47 to 0.23)	0.3
Perceived behavioural control	1.07 (0.94 to 1.20)	0.95 (0.82 to 1.08)	1.02 (0.90 to 1.14)	0.95 (0.83 to 1.07)	0.96 (0.81 to 1.11)	0.94 (0.80 to 1.10)	−0.05 (−0.13 to 0.02)	0.00 (−0.08 to 0.08)	−0.11 (−0.26 to 0.04)	−0.01 (−0.15 to 0.15)	−0.05 (−0.16 to 0.06)	−0.10 (−0.31 to 0.11)	0.2
Preventive behaviours included in the intervention (%)‡													
Warming up	50.6 (41.6 to 59.4)	52.5 (43.6 to 61.3)	49.8 (41.8 to 57.5)	48.2 (40.5 to 56.0)	49.1 (38.6 to 59.2)	43.9 (33.6 to 54.1)	−0.7 (−6.5 to 4.9)	−4.3 (−9.9 to 1.3)	−1.5 (−13.0 to 9.7)	−8.6 (−19.9 to 2.7)	3.6 (−4.3 to 11.6)	7.2 (−8.6 to 23.1)	4.2
Cooling down	44.3 (35.6 to 53.0)	38.7 (30.2 to 47.3)	42.8 (35.3 to 50.2)	36.2 (28.7 to 43.6)	41.3 (31.3 to 51.6)	33.7 (23.8 to 44.0)	−1.5 (−7.0 to 4.4)	−2.5 (−8.2 to 3.3)	−3.0 (−14.1 to 8.9)	−5.0 (−16.4 to 6.5)	1.0 (−7.2 to 8.9)	2.0 (−14.5 to 17.8)	1.5
Trail running shoes	56.0 (47.3 to 64.9)	58.4 (49.8 to 67.1)	50.5 (42.9 to 58.1)	50.0 (42.6 to 57.6)	44.9 (34.7 to 55.2)	41.6 (31.4 to 51.9)	−5.5 (−11.3 to 0.2)	−8.4 (−14.2 to −2.7)†	−11.0 (−22.6 to 0.5)	−16.8 (−28.4 to −5.3)†	2.9 (−5.2 to 11.0)	5.8 (−10.4 to 22.0)	3.1
Strength training	48.0 (39.4 to 57.1)	43.7 (35.1 to 52.5)	43.1 (35.2 to 50.8)	45.2 (37.5 to 53.0)	38.2 (27.9 to 48.4)	46.7 (36.4 to 56.8)	−4.9 (−10.5 to 0.7)	1.5 (−4.2 to 6.9)	−9.8 (−20.9 to 1.4)	3.0 (−8.5 to 13.8)	−6.4 (−14.3 to 1.5)	−12.8 (−28.6 to 3.1)	0.1
Core training	57.7 (48.7 to 66.5)	53.1 (44.2 to 61.9)	55.9 (48.1 to 63.7)	52.7 (44.7 to 60.3)	54.1 (43.8 to 64.2)	52.3 (41.9 to 62.4)	−1.8 (−7.3 to 3.7)	−0.4 (−5.9 to 5.1)	−3.5 (−14.6 to 7.5)	−0.8 (−11.8 to 10.2)	−1.4 (−9.2 to 6.4)	−2.7 (−18.4 to 12.7)	0.6
Neuromuscular training	30.2 (22.4 to 38.0)	27.0 (19.3 to 34.7)	26.2 (19.3 to 33.1)	24.8 (17.9 to 31.7)	22.2 (13.0 to 31.1)	22.7 (13.5 to 31.5)	−4.0 (−8.9 to 0.8)	−2.2 (−6.9 to 2.8)	−8.0 (−17.8 to 1.6)	−4.3 (−13.9 to 5.5)	−1.9 (−8.9 to 4.8)	−3.7 (−17.8 to 9.6)	0.4
Flexibility training	41.4 (32.7 to 49.8)	36.2 (27.6 to 44.5)	36.3 (28.8 to 43.9)	35.6 (28.0 to 43.0)	31.3 (21.4 to 41.2)	35.0 (25.1 to 44.9)	−5.0 (−10.3 to 0.5)	−0.6 (−6.1 to 4.7)	−10.1 (−20.6 to 1.0)	−1.2 (−12.2 to 9.4)	−4.4 (−12.2 to 3.2)	−8.8 (−24.4 to 6.4)	0.1
Preventive behaviours not included in the intervention (%)‡													
Compression clothing	7.2 (3.1 to 11.4)	3.9 (0.0 to 8.1)§	7.1 (3.5 to 10.6)	5.2 (1.6 to 8.7)	7.0 (2.1 to 11.9)	6.6 (1.8 to 11.6)	−0.1 (−3.0 to 2.8)	1.4 (−1.6 to 4.2)	−0.2 (−6.0 to 5.6)	2.8 (−3.1 to 8.5)	−1.5 (−5.7 to 2.5)	−2.9 (−11.4 to 5.1)	0.3
Compression stocking	30.4 (22.6 to 38.1)	22.6 (15.0 to 30.3)	26.9 (19.9 to 33.8)	21.9 (15.2 to 29.0)	23.4 (14.7 to 32.2)	21.3 (12.6 to 30.2)	−3.5 (−8.0 to 0.9)	−0.7 (−5.1 to 3.8)	−7.0 (−15.9 to 1.9)	−1.3 (−10.1 to 7.6)	−2.8 (−9.2 to 3.5)	−5.7 (−18.4 to 6.9)	0.2
Insoles	16.2 (10.0 to 22.6)	15.6 (9.4 to 21.9)	13.8 (8.1 to 19.4)	13.8 (8.3 to 19.4)	11.3 (4.0 to 18.5)	12.1 (4.8 to 19.1)	−2.5 (−6.2 to 1.3)	−1.8 (−5.5 to 2.0)	−4.9 (−12.5 to 2.7)	−3.5 (−11.1 to 4.0)	−0.7 (−6.1 to 4.5)	−1.4 (−12.2 to 9.0)	0.7
Stretching before	30.6 (22.4 to 38.7)	29.6 (21.6 to 37.8)	29.0 (21.6 to 36.2)	29.6 (22.4 to 36.9)	27.3 (18.1 to 36.7)	29.7 (20.4 to 39.0)	−1.7 (−6.5 to 3.1)	0.0 (−4.8 to 4.7)	−3.3 (−13.0 to 6.2)	0.1 (−9.7 to 9.5)	−1.7 (−8.4 to 5.2)	−3.4 (−16.8 to 10.4)	0.4
Stretching after	45.3 (36.4 to 54.2)	46.4 (37.6 to 55.2)	43.0 (35.1 to 50.9)	46.6 (38.8 to 54.5)	40.7 (30.6 to 50.9)	46.7 (36.6 to 56.7)	−2.3 (−7.6 to 3.1)	0.2 (−5.1 to 5.5)	−4.6 (−15.2 to 6.1)	0.3 (−10.2 to 10.9)	−2.5 (−9.9 to 5.2)	−5.0 (−19.8 to 10.4)	0.3
Supervised training	29.1 (21.8 to 36.7)	19.9 (12.6 to 27.3)	26.0 (19.4 to 32.7)	19.0 (12.4 to 25.6)	22.9 (14.5 to 31.6)	18.1 (9.7 to 26.8)	−3.1 (−7.5 to 1.5)	−0.9 (−5.5 to 3.4)	−6.1 (−14.9 to 3.1)	−1.8 (−11.0 to 6.8)	−2.2 (−8.5 to 4.1)	−4.3 (−17.1 to 8.3)	0.3
Taping	6.3 (2.4 to 10.4)	5.1 (1.2 to 9.0)	7.4 (4.1 to 10.8)	3.4 (0.1 to 6.8)	8.4 (3.8 to 13.1)	1.8 (0.0 to 6.5)§	1.0 (−1.8 to 3.8)	−1.7 (−4.4 to 1.2)	2.1 (−3.5 to 7.7)	−3.3 (−8.8 to 2.4)	2.7 (−1.2 to 6.7)	5.4 (−2.4 to 13.4)	10.1
Running-related injury (%)‡	46.3 (39.4 to 53.5)	37.7 (30.6 to 44.6)	42.3 (35.9 to 48.7)	36.9 (30.6 to 43.4)	30.3 (22.9 to 37.8)	34.8 (27.4 to 42.2)	−4.0 (−5.8 to −2.1)†	−0.7 (−2.5 to 1.1)	−16.0 (−23.0 to −8.6)†	−2.8 (−9.9 to 4.2)	−3.3 (−5.8 to −0.8)¶	−13.1 (−23.3 to −3.1)¶	194.3

Results regarding the effects between groups are in favour of the intervention group.
*Effect sizes are expressed as mean differences obtained by Bayesian linear mixed models.
†95% BCI not containing the null effect (ie, zero) for within-group and between-group effects.
‡Effect sizes are expressed as absolute risk difference obtained by Bayesian linear probability mixed models.
§The lower bound of the 95% BCI of these estimates was negative. As probability (non-comparative) cannot be negative, the lower bound of the 95% BCI of these estimates was constrained to zero.
¶Significant results (ie, 95% BCI not containing the null effect and BF>3 for within-group and between-group effects).
BCI, Bayesian highest posterior density credible interval; BF, Bayes factor (calculated for the regression coefficient of the interaction term composed by group and time); ES, effect size.

Table 5 Adherence to the online tailored advice (*TrailS*$_6$) in the intervention group (n=115)

	Intervention received		
Intervention component	No RRI Mean % (95% BCI)	Non-substantial RRI Mean % (95% BCI)	Substantial RRI Mean % (95% BCI)
Following at least one advice	66.6 (58.4 to 74.7)	77.6 (69.1 to 86.0)	90.1 (83.6 to 96.7)
Core training	39.6 (31.7 to 47.5)	36.9 (27.1 to 46.7)	43.1 (32.9 to 53.2)
Strength training	34.5 (26.2 to 42.7)	41.1 (31.3 to 50.7)	36.0 (26.6 to 45.2)
Flexibility training	25.6 (18.3 to 33.0)	30.9 (21.7 to 40.2)	34.5 (24.9 to 44.7)
Neuromuscular training	15.9 (10.0 to 22.0)	14.3 (6.8 to 21.7)	21.8 (13.1 to 30.7)
Warming up	28.4 (20.8 to 36.1)	27.1 (17.4 to 36.4)	25.5 (16.2 to 34.5)
Cooling down	27.2 (19.6 to 34.8)	21.7 (13.5 to 30.2)	21.6 (12.4 to 30.3)
Trail running shoes	25.6 (18.4 to 32.7)	17.8 (11.2 to 24.7)	15.9 (8.8 to 22.8)
Trail running shoes (n of pairs)	24.8 (18.3 to 31.5)	22.5 (15.0 to 30.0)	14.8 (7.7 to 22.0)
Longer recovery period	13.6 (9.1 to 18.1)	22.3 (13.7 to 30.6)	26.8 (18.1 to 35.6)
Reduction of running exposure	11.0 (7.6 to 14.5)	22.0 (14.5 to 29.8)	37.9 (29.0 to 46.8)
Slow progression after reduction	–	20.6 (13.2 to 28.0)	27.7 (20.2 to 35.2)
Medical attention	–	14.6 (8.2 to 20.8)	34.2 (24.4 to 43.9)
RICE	–	5.4 (2.1 to 8.6)	10.2 (3.7 to 16.5)
No advice	33.4% (25.2 to 41.5)	22.3 (14.0 to 30.6)	9.9 (3.3 to 16.4)

The results are expressed as the average percentage over time and its 95% BCI obtained by Bayesian linear probability mixed models.
BCI, Bayesian highest posterior density credible interval. RICE, rest, ice, compression and elevation; RRI, running-related injury.

component of the intervention was reported in order to tailor future prevention programmes to the components with higher adherence, or to create strategies to increase the adherence of those less performed. This study can be classified as a pragmatic randomised controlled trial, in other words an effectiveness trial, due to its characteristics such as[20 26] (1) a non-restrictive eligibility criteria, (2) the participatory approach applied during the development of the *TrailS*$_6$ intervention, (3) the intervention flexibility (ie, the participants could choose to perform the most suitable advice to them), (4) the 'usual care' characteristic of the control group (explained in the methods), (5) the adherence flexibility to the intervention (a reality in 'real world') and (6) the intention-to-treat analyses.

Although the sample of trail runners included in this study is likely to be representative of the Dutch trail running community,[11] this study was composed of a convenience sample. Blinding of participants was not possible because of the impossibility to develop a sham intervention mimicking the online tailored intervention evaluated in this study. Because the effects of the intervention included primary, secondary and tertiary prevention,[24] specific effects on each prevention level might be latent in the results. However, this study had no sufficient power for a subgroup analysis in order to investigate the effects of the intervention in each level of prevention. Last but not least, the implementation of a minimal intervention in the control group may have resulted in an attenuation of the effectiveness of the online tailored intervention.

Implications for practice and recommendations

The strength of evidence supporting a significant preventive effect of online tailored advice on RRIs was classified as 'very strong', suggesting that its implementation in practice may be supported by this evidence. This is relevant because online interventions are inexpensive, easy to implement and reachable for a large number of people.[18 19] Tailored advice may constitute a basic preventive component in a multicomponent prevention programme, including, for example, supervised strengthening and proprioceptive training.[43 44] Adding the preventive effects of these interventions may enhance the likelihood of preventing RRIs. Therefore, online tailored advice may be used as a tool to RRI prevention, but maybe it should not be used as a stand-alone approach. However, multicomponent interventions aimed at preventing RRIs still need to be developed and evaluated in randomised controlled trials.

The average adherence to the intervention found in the current study varied from 66.6% to 90.1%, suggesting that online tailored advice may be successfully implemented in practice.[45] Nonetheless, future efforts on adapting, developing or implementing tailored advice on RRI prevention should focus on the components with the highest adherence presented in this study and/or develop additional strategies to enhance the components

What are the findings?

- The addition of online tailored advice adjusted every 2 weeks for the running-related injury (RRI) classification generated by the Oslo Sports Trauma Research Centre Questionnaire on Health Problems (ie, no injury, non-substantial injury or substantial injury) to general advice was effective on preventing RRIs when compared with online general advice given only at baseline.
- The addition of online tailored advice to general advice seems to be ineffective for changing individual preventive behaviours towards the prevention of RRIs when compared with online general advice given only at baseline.

How might it impact on clinical practice in the future?

- Online tailored advice may constitute a preventive component in multicomponent prevention programmes in order to enhance the likelihood of preventing RRIs.
- One out of eight trail runners receiving online tailored advice (*TrailS*$_6$) every 2 weeks rather than receiving general advice given only at baseline may benefit from an RRI preventive effect over 6 months.

with lower adherence. Adding informative videos and/or online instantaneous feedback with human interaction (eg, live video consultations) may be suggestions to increase adherence. In addition, long-term effects (≥12 months) and implementation outcomes of online tailored interventions should be investigated.

CONCLUSIONS

There was a 'very strong' evidence (BF 194.3) supporting a significant (ARD −13.1%, 95% BCI −23.3 to −3.1) preventive effect (NNT 8, 95% BCI 3 to 22) of adding online tailored advice to general advice on the prevention of RRIs after 6 months of follow-up. Therefore, online tailored advice may be used as a preventive component in RRI prevention programmes. No effect was observed on determinants and actual preventive behaviours towards RRI prevention.

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REFERENCES

1 Hallal PC, Andersen LB, Bull FC, *et al*. Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet* 2012;380:247–57.
2 Kohl HW, Craig CL, Lambert EV, *et al*. The pandemic of physical inactivity: global action for public health. *Lancet* 2012;380:294–305.
3 World Health Organization (WHO). *Global Status Report on Noncommunicable Diseases*. Geneva: World Health Organization, 2014.
4 Stamatakis E, Chaudhury M. Temporal trends in adults' sports participation patterns in England between 1997 and 2006: the health survey for England. *Br J Sports Med* 2008;42:601–8.
5 VeiligheidNL. Sportblessures. Blessurecijfers: VeiligheidNL. 2015.
6 Chakravarty EF, Hubert HB, Lingala VB, *et al*. Reduced disability and mortality among aging runners: a 21-year longitudinal study. *Arch Intern Med* 2008;168:1638–46.
7 Hespanhol Junior LC, Pillay JD, van Mechelen W, *et al*. Meta-analyses of the effects of habitual running on indices of health in physically inactive adults. *Sports Med* 2015;45:1455–68.
8 Lee DC, Pate RR, Lavie CJ, *et al*. Leisure-time running reduces all-cause and cardiovascular mortality risk. *J Am Coll Cardiol* 2014;64:472–81.
9 Hatziandreu EI, Koplan JP, Weinstein MC, *et al*. A cost-effectiveness analysis of exercise as a health promotion activity. *Am J Public Health* 1988;78:1417–21.
10 Ooms L, Veenhof C, de Bakker DH. Effectiveness of start to run, a 6-week training program for novice runners, on increasing health-enhancing physical activity: a controlled study. *BMC Public Health* 2013;13:697.
11 Hespanhol Junior LC, van Mechelen W, Verhagen E. Health and economic burden of running-related injuries in Dutch trailrunners: a prospective cohort study. *Sports Med* 2017;47:367–77.
12 Hespanhol Junior LC, van Mechelen W, Postuma E, *et al*. Health and economic burden of running-related injuries in runners training for an event: a prospective cohort study. *Scand J Med Sci Sports* 2016;26:1091–9.
13 Hespanhol Junior LC, Huisstede BM, Smits DW, *et al*. The NLstart2run study: economic burden of running-related injuries in novice runners participating in a novice running program. *J Sci Med Sport* 2016;19:800–4.
14 Bredeweg SW, Zijlstra S, Bessem B, *et al*. The effectiveness of a preconditioning programme on preventing running-related injuries in novice runners: a randomised controlled trial. *Br J Sports Med* 2012;46:865–70.
15 Knapik JJ, Trone DW, Tchandja J, *et al*. Injury-reduction effectiveness of prescribing running shoes on the basis of foot arch height: summary of military investigations. *J Orthop Sports Phys Ther* 2014;44:805–12.
16 Malisoux L, Chambon N, Delattre N, *et al*. Injury risk in runners using standard or motion control shoes: a randomised controlled trial with participant and assessor blinding. *Br J Sports Med* 2016;50:481–7.
17 Yeung SS, Yeung EW, Gillespie LD. Interventions for preventing lower limb soft-tissue running injuries. *Cochrane Database Syst Rev* 2011:CD001256.
18 Adriaensens L, Hesselink A, Fabrie M, *et al*. Effectiveness of an online tailored intervention on determinants and behaviour to prevent running related sports injuries: a randomised controlled trial. *Schweizerische Zeitschrift für Sportmedizin und Sporttraumatologie* 2014;62:6–13.
19 Verhagen EA, Clarsen B, Bahr R. A peek into the future of sports medicine: the digital revolution has entered our pitch. *Br J Sports Med* 2014;48:739–40.
20 Loudon K, Treweek S, Sullivan F, *et al*. The PRECIS-2 tool: designing trials that are fit for purpose. *BMJ* 2015;350:h2147.
21 Twisk JWR. Sample size calculation. Twisk JWR, ed. *Applied Longitudinal Data Analysis for Epidemiology*. 2 ed. Cambridge: Cambridge University Press, 2013:237–42.
22 Verhagen E, Voogt N, Bruinsma A, *et al*. A knowledge transfer scheme to bridge the gap between science and practice: an integration of existing research frameworks into a tool for practice. *Br J Sports Med* 2014;48:698–701.
23 Clarsen B, Rønsen O, Myklebust G, *et al*. The oslo sports trauma research center questionnaire on health problems: a new approach to prospective monitoring of illness and injury in elite athletes. *Br J Sports Med* 2014;48:754–60.
24 Drew MK, Cook J, Finch CF. Sports-related workload and injury risk: simply knowing the risks will not prevent injuries. *Br J Sports Med* 2016.
25 McKay CD, Verhagen E. 'Compliance' versus 'adherence' in sport injury prevention: why definition matters. *Br J Sports Med* 2016;50:382–3.
26 Thompson BT, Schoenfeld D. Usual care as the control group in clinical trials of nonpharmacologic interventions. *Proc Am Thorac Soc* 2007;4:577–82.
27 Ajzen I. The theory of planned behavior. *Organ Behav Hum Decis Process* 1991;50:179–211.
28 Ajzen I. *Attitudes, personality and behavior*. Maidenhead: Open University Press, 2005. 2 ed.
29 de Bruijn GJ, Kremers SP, Schaalma H, *et al*. Determinants of adolescent bicycle use for transportation and snacking behavior. *Prev Med* 2005;40:658–67.
30 de Bruijn GJ, Kremers SP, Lensvelt-Mulders G, *et al*. Modeling individual and physical environmental factors with adolescent physical activity. *Am J Prev Med* 2006;30:507–12.
31 Pluim BM, Loeffen FG, Clarsen B, *et al*. A one-season prospective study of injuries and illness in elite junior tennis. *Scand J Med Sci Sports* 2016;26:564–71.
32 Fuller CW, Bahr R, Dick RW, *et al*. A framework for recording recurrences, reinjuries, and exacerbations in injury surveillance. *Clin J Sport Med* 2007;17:197–200.
33 Lesaffre E, Lawson AB. *Bayesian Biostatistics*. Chichester: John Wiley & Sons, Ltd, 2012.
34 Albert J. Single-parameter models. Albert J, ed. *Bayesian Computation with R* New York, NY: Springer , 2009:39–61.
35 Gelman A, Jakulin A, Pittau MG, *et al*. A weakly informative default prior distribution for logistic and other regression models. *Ann Appl Stat* 2008;2:1360–83.
36 Gelman A. Prior distributions for variance parameters in hierarchical models (comment on article by browne and draper). *Bayesian Anal* 2006;1:515–34.
37 Hoffman MD, Gelman A. The no-u-turn sampler: adaptively setting path lengths in hamiltonian monte carlo. *Journal of Machine Learning Research* 2014;15:1593–623.
38 Kass RE, Raftery AE. Bayes factors. *J Am Stat Assoc* 1995;90:773–95.
39 Dienes Z. Using bayes to get the most out of non-significant results. *Front Psychol* 2014;5:781.
40 Thabane L. A closer look at the distribution of number needed to treat (NNT): a Bayesian approach. *Biostatistics* 2003;4:365–70.
41 Higgins JPT, Green S, eds. Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 the Cochrane Collaboration, 2011. http://handbook.cochrane.org (accessed 03 Aug 2016).
42 Moher D, Hopewell S, Schulz KF, *et al*. CONSORT 2010 explanation and elaboration: updated guidelines for reporting parallel group randomised trials. *J Clin Epidemiol* 2010;63:e1–e37.
43 Lauersen JB, Bertelsen DM, Andersen LB. The effectiveness of exercise interventions to prevent sports injuries: a systematic review and meta-analysis of randomised controlled trials. *Br J Sports Med* 2014;48:871–7.
44 Leppänen M, Aaltonen S, Parkkari J, *et al*. Interventions to prevent sports related injuries: a systematic review and meta-analysis of randomised controlled trials. *Sports Med* 2014;44:473–86.

45 Durlak JA, DuPre EP. Implementation matters: a review of research on the influence of implementation on program outcomes and the factors affecting implementation. *Am J Community Psychol* 2008;41:327–50.
46 Lopes AD, Hespanhol Júnior LC, Yeung SS, *et al*. What are the main running-related musculoskeletal injuries? a systematic review. *Sports Med* 2012;42:891–905.
47 Saragiotto BT, Yamato TP, Hespanhol Junior LC, *et al*. What are the main risk factors for running-related injuries? *Sports Med* 2014;44:1153–63.
48 van Gent RN, Siem D, van Middelkoop M, *et al*. Incidence and determinants of lower extremity running injuries in long distance runners: a systematic review. *Br J Sports Med* 2007;41:469–80.

Effectiveness of online tailored advice to prevent running-related injuries and promote preventive behaviour in Dutch trail runners: a pragmatic randomised controlled trial

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