Preventing ankle sprain recurrences in sports

Hupperets, M.D.W.

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Substantial monetary benefits through injury prevention: economic evaluation of a randomized controlled trial on prevention of ankle sprain recurrences

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ABSTRACT

Background The most common ankle injury is the lateral ankle sprain. Dutch annual sports related ankle sprain costs can roughly be estimated at €84,200,000. Research has shown that proprioceptive training account for an approximated overall 50% reduction in ankle sprain recurrence rate.

Hypothesis Significant reduction in costs after the introduction of an unsupervised proprioceptive training programme, that was applied after usual care of individual athletes who recently had sustained an acute sports-related lateral ankle ligament injury, in comparison with usual care.

Design Cost-effectiveness analysis alongside a randomized controlled trial.

Methods 522 male and female athletes; 256 athletes (120 female and 136 male) in the intervention group; 266 athletes (128 female and 138 male) in the control group. Both groups received treatment according to usual care. Athletes allocated to the intervention group received an eight-week proprioceptive training programme additional to usual care. Costs related to ankle sprain recurrences were measured from a societal perspective using cost diaries. Bootstrapping was used to analyze the cost-effectiveness data. Follow-up was one year.

Results Mean total costs in the intervention group were €46 (standard deviation €156) per athlete and €117 (€325) per injured athlete. Mean overall costs in the control group were €149 (€836) per athlete and €447 (€1,403) per injured athlete. Statistically significant differences in total costs were found per athlete (mean difference −€103; 95% confidence interval −€253 to −€23) and per injured athlete (−€332; −€741 to −€62) in favour of the intervention group. Cost-effectiveness planes showed the effect of the intervention was larger and the costs were lower in the intervention group than the control group.

Conclusions The use of a proprioceptive training programme after usual care of an ankle sprain is cost-effective for the prevention of ankle sprain recurrences in comparison with usual care alone. In the Netherlands, an estimated annual €24.1M in medical and lost productivity costs can be saved solely by advocating a proprioceptive training programme as in the present study.

INTRODUCTION

Worldwide, acute ankle injury is one of the most common musculoskeletal injuries. The most common ankle injury is the lateral ankle sprain.[26,33] Daily, an estimated 23,000 ankle sprains occur in the United States, which equals about one ankle sprain per 10,000 persons per day.[12] From Verhagen et al.[31] an estimate of the absolute risk of ankle sprains is about 1/1000 hours of sports. Sports and physical activity related ankle sprains place a high demand on health care systems and are associated with high medical and lost productivity costs. For example, in the United States, an estimated 1,600,000 physician office visits and over 8,000 hospitalizations per year were registered for sprains to the ankle or foot.[16] Another example comes from a recent Dutch study, which showed mean total costs of one ankle sprain of approximately €360.[31] In 2003, a total of 234,000 ankle sprains were registered, of which 110,000 required medical treatment.[32] Dutch annual sports related ankle sprain costs can roughly be estimated at €84,200,000. Productivity loss due to absence from paid and unpaid work was responsible for up to 80% of these costs.[31]

A reduction of ankle sprain incidence through preventive measures is warranted. Several intervention strategies have been evaluated for the prevention of ankle sprains, including external support[9,25], specific technical training[1], and proprioceptive training.[17,18,25] Research has shown that proprioceptive training and bracing each account for an approximated overall 50% reduction in ankle sprain recurrence rate.[29] Furthermore, preventive measures as taping, bracing, and proprioceptive training seem only effective in persons with a history of ankle sprains.[29]

Despite economic evaluations are now widely accepted in health care research[7,28,34], cost-effectiveness analyses are scarce in the field of sports injury prevention. To date, only two studies reported on cost-effectiveness of interventions for prevention of ankle sprains.[19,31]

This economic evaluation evaluated the cost-effectiveness of an individual home-based proprioceptive training programme aimed at the prevention of ankle sprain recurrences in athletes with a recently sustained ankle sprain, to be used after treatment by usual care in comparison with usual care alone.

METHODS

The main study design and intervention are described in detail in our associated paper.[11] Briefly, a randomized controlled trial was conducted in which athletes recruited through medical channels (eleven hospital emergency rooms, five general practices, four physical therapy offices) and non-medical channels (i.e. newspapers, sports magazines, sports tournaments, and the internet) were randomized to a control group or an intervention group. Both groups received treatment according to usual care. Athletes allocated to the intervention group received an additional eight-week proprioceptive training programme after treatment by usual care. The full programme is described elsewhere.[10] The intervention programme consisted of three proprioceptive training sessions per week, with a maximum duration of 30 minutes per session.

During the one-year follow-up, athletes reported all sudden inversions of the same ankle and details of their sports participation for each training session and match on a monthly basis. Ankle sprain recurrences were registered by self-report. In case of an ankle sprain recurrence a web-based ankle sprain registration form, derived from a previously used injury registration form[30], was completed. Alongside this form, athletes received a cost-diary, which registered all absence from work, school and other chores of life, and all health care utilization (including use of medication) from the moment of injury until full recovery. A societal perspective was adopted for the economic evaluation.

Data collection

Table 1 provides an overview of the costs that were identified, measured, and valued.[6,20] Costs of the intervention included costs directly related to the implementation of the intervention programme. These costs included written information materials, an instructional DVD, development and maintenance of an informational website, and a balance board (Avanco AB, Sweden). In addition to the costs of the intervention itself, costs of health care utilization were included, for example, visits to a general practitioner, physiotherapist, alternative therapist, care by a sports physician or medical specialist, and hospital care as well as the use of medication and medical devices. Standard prices were used to value health care utilization if available.[20] The costs of medication were estimated on the basis of prices recommended by the Royal Dutch Society of Pharmacy.[24] Costs of production loss due to absenteeism from paid or unpaid work were also included. Costs of absenteeism from paid work were estimated using the friction cost approach with a friction period of 4 months and based on the mean age and sex-specific income of the Dutch population.[6,14] Costs of productivity loss due to unpaid work, such as study and household work, were estimated at a shadow price of €8.78 an hour.[20]

Data analysis

Complete cost diaries were returned by 42 (75%) injured athletes of the intervention group, and by 66 (74%) injured athletes of the control group. The injured non-completers did not differ significantly from the injured completers regarding gender, age, athlete's sports experience in years, and general monthly sports exposure (data not shown). Missing cost data were completed through multiple imputation by means of Multiple Imputation by Chained Equations procedure[27] using R statistical software.[21]

Five multiple imputed datasets were generated and these were then combined into one using Rubin's rules.[22] Bootstrapping was used to calculate confidence intervals around cost differences to account for the skewed cost distributions. "Approximate bootstrap confidence" (ABC) intervals were estimated as proposed by Efron[8] and applied in a clinical study by Burton et al.[4] The incremental cost-effectiveness ratio presents the incremental costs of the proprioceptive training programme to prevent one ankle sprain recurrence in comparison with usual care alone.

The ICER relates the differences in costs and effects between intervention and control. It can be calculated as follows:

$$\text{ICER} = \frac{(Ci - Cc)}{(Ei - Ec)} = \frac{\Delta C}{\Delta E}$$

Where C_I = mean costs in the intervention group, C_C = mean costs in the control group, E_I = mean effects in the intervention group, and E_C = mean effects in the control group. The ICER represents the additional costs of the proprioceptive training programme in comparison with usual care to prevent one ankle sprain recurrence. Uncertainty surrounding the incremental cost-effectiveness ratio was shown on a cost-effectiveness plane, using non-parametric bootstrapping with 5,000 replications.[2,5] A cost-effectiveness acceptability curve was estimated to show the probability that the intervention was cost-effective in comparison with usual care alone for various ceiling ratios, which is the maximum amount of money a decision maker is willing to pay to gain one unit of effect extra.[15]

Table 1 Costs applied in the economic evaluation of a proprioceptive training programme for the prevention of ankle sprains.

Costs	Cost (€)
Intervention costs (per athlete)	27.50
Balance board	20.00
Written information materials	3.50
Instructional DVD	2.00
Development and maintenance of website	2.00
Health care costs (direct costs):	
General practitioner (per visit = 20 min)*	21.36
General practitioner (phone consult)*	10.68
Physical therapist (per visit = 30 min)*	24.06
Sports physician (per visit)	68.17
Medical specialist (per visit)*	71.92
Emergency room (per visit) †	147.01
Drugs‡	-
Medical devices‡	
Tape (per roll)	3.82
Brace	86.49
Costs of productivity loss (indirect costs) :	
Absenteeism from paid work (per day)§	-
Absenteeism from unpaid work (per hour)*	8.78

€1.00 = £0.90, US $1.36 (d.d. 28-01-2009)
* Guideline price according to Dutch guidelines[20]
† Cost price according to hospital administration of VU Medical Center
‡ Price according to tariff of the Royal Dutch Society of Pharmacy[22]
§ Indirect costs for paid work was calculated for each injured separately based on mean income of the Dutch population according to age and sex[20]

The imputed data were used in the primary cost-effectiveness analysis. A sensitivity analysis was performed including only complete cases for which all health care utilization data and cost data were available.

RESULTS

A total of 522 athletes were randomly assigned to the intervention group (N=256) or to the control group (N=266). At baseline there were no significant differences between the two groups on any of the baseline variables.[11] During the one year follow-up, 145 athletes reported an ankle sprain recurrence: 56/256 (22%) in the intervention group and 89/266 (33%) in the control group. For a full overview of statistical analyses, please see our associated paper.[11] In brief, Cox regression analysis, comparing risk of recurrence of ankle sprain between groups, showed a significantly lower risk of recurrence in the intervention group than in the control group (relative risk 0.63. 95% confidence interval 0.45 to 0.88). Furthermore, as shown in Hupperets et al.[11], nine people needed to be treated to prevent one ankle sprain recurrence.

Costs per athlete

Total costs per athlete in the intervention group were €27.50 (Table 1). Mean total costs in the intervention group were €46 (standard deviation €156) per athlete and €149 (€836) per control group athlete. There was a statistically significant total costs difference of −€103 (95% confidence interval −€253 to −€23) per athlete between the intervention group and the control group, meaning a cost-benefit of €103 in favour of the intervention group (Table 2). Total health care costs per athlete and costs of productivity loss per athlete were significantly higher in the control group compared to the intervention group (−€15; −€28 to −€5 and −€115; −€260 to −€39, respectively).

Costs per injured athlete

Mean overall costs in the intervention group were €117 (€325) per injured athlete and €447 (€1,403) per injured athlete in the control group. Per injured athlete, a statistically significant total cost difference of −€332 (−€741 to −€62) was found between groups in favour of the intervention group (Table 2). Total health care costs per injured athlete (−€38; −€74 to −€2) and costs of productivity loss per injured athlete (−€322; −€721 to −€64) were significantly higher in the control group compared to the intervention group.

Cost-effectiveness analysis

The incremental cost-effectiveness ratio of the intervention in comparison with usual care was −889. The ICER of −889 is based on a difference in mean cost of −€102.96 and a difference in mean effects of 11.58%. This means that prevention of one ankle sprain recurrence in the intervention group is associated with €889 cost savings per prevented recurrent ankle sprain. Thus, the effect of the intervention was larger and the costs were lower in the intervention group compared to the control group. Figure 1 shows the cost-effectiveness plane for ankle sprain recurrence difference for intervention group versus control group.

Sensitivity analysis

The sensitivity analysis (Table 3) addressed three areas of uncertainty. As the cost of the intervention was relatively low, we looked at the impact of higher intervention costs. Instead of total intervention costs of €27.50, we performed similar analyses with total intervention costs of €45. Total cost differences per athlete were still significant between groups (−€85; −€235 to −€5). We found an ICER of −763.

Table 2 Mean (standard deviation) total direct, total indirect, and overall total costs (€) per athlete and per injured athlete and differences in mean total costs (95% confidence intervals) per athlete and per injured athlete during follow-up of 12 months after multiple imputation.

Costs per athlete	Intervention (n=256)	Control (n=266)	Difference
Intervention	27.50	-	27.50
Direct	5.02 (29.79)	20.42 (79.93)	−15.40* (−28.29 to −5.48)
Indirect	13.91 (132.81)	128.98 (804.69)	−115.06* (−259.94 to −39.11)
Overall	46.44 (155.50)	149.40 (835.83)	−102.96* (−252.54 to −22.59)

Costs per injured athlete	Intervention (n=56)	Control (n=89)	Difference
Intervention	27.50	-	27.50
Direct	22.97 (60.76)	61.04 (129.34)	−38.07* (−74.29 to −2.29)
Indirect	63.61 (285.66)	385.48 (1,360.08)	−321.88* (−721.29 to −64.19)
Overall	114.07 (324.78)	446.52 (1,403.39)	−332.45* (−741.13 to −62.36)

95% confidence interval obtained by calculating ABC intervals

* denotes a statistically significant difference (*P*=.05)

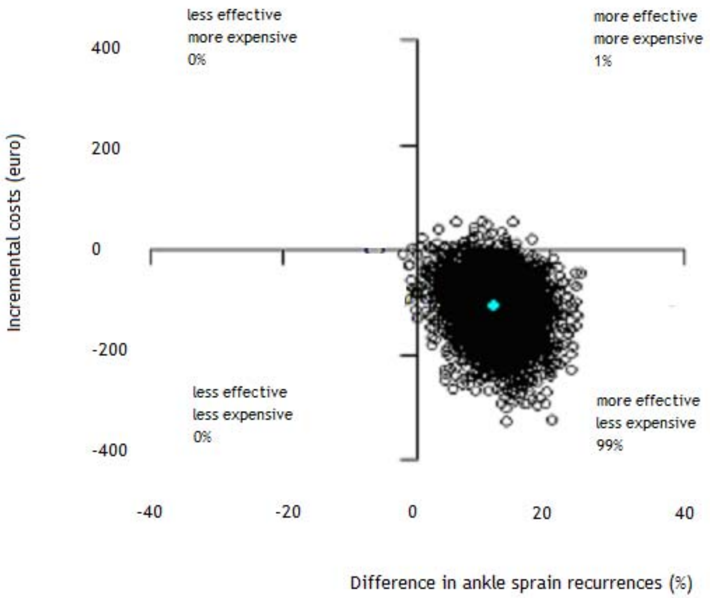

Figure 1 Cost-effectiveness plane presenting cost-effect pairs estimated by using bootstrapping (1,000 samples) in each multiply imputed data set plane for ankle sprain recurrence risk difference for the intervention group versus control group. The central lighter dot indicates the point estimate of the incremental cost-effectiveness ratio. A total of 99% of the bootstrapped cost-effect pairs are in the southeast quadrant, indicating that in the intervention group there were significantly lower costs and fewer ankle sprain recurrences as compared to the control group.

Second, we looked at the effect of limited production losses due to disease. Costs of absence from work shorter than the friction period are calculated as being 80% of the production value during the period of absence.[13] A friction period of 4 months was used in the present study. All athletes were absent from work shorter than the friction period. Elasticity of lost production costs did not influence significance of results (Table 3).

Table 3 Sensitivity analysis addressing three areas of uncertainty. Values are mean (standard deviation) total direct, total indirect, and overall total costs (€) per athlete and differences in mean total costs (95% confidence intervals) per athlete.

	Intervention (n=256)	Control (n=266)	Difference
Higher intervention costs			
Intervention	45	-	45
Direct	5 (30)	20 (80)	−15* (−28 to −5)
Indirect	14 (133)	129 (805)	−115* (−260 to −39)
Overall	64 (155)	149 (836)	−85* (−235 to −5)
Elasticity of friction costs			
Intervention	27.50	-	27.50
Direct	5 (30)	20 (80)	−15* (−28 to −5)
Indirect	11 (111)	103 (644)	−92* (−209 to −31)
Overall	44 (129)	124 (676)	−80* (−203 to −15)

95% confidence interval obtained by calculating ABC intervals

* denotes a statistically significant difference (*P*=.05)

Table 3 cont. Sensitivity analysis addressing three areas of uncertainty.

	Intervention (n=242)	Control (n=243)	Difference
Complete case analysis			
Intervention	27.50	-	27.50
Direct	3 (22)	18 (77)	−15* (−28 to −5)
Indirect	6 (44)	123 (794)	−117* (−275 to −47)
Overall	37 (60)	141 (827)	−104* (−258 to −29)

95% confidence interval obtained by calculating ABC intervals
* denotes a statistically significant difference (*P*=.05)

Finally, we looked at the effect of imputing data relating to personal costs and effects that were missing from the questionnaire responses. Cost utilization data for complete cases are presented in Table 4. In the complete case analysis mean costs per athlete in the intervention group were €37 (€60) and €141 (€827) for the control group. This led to a statistically significant cost difference of −€104 (−€258 to −€29) per athlete. Cost-effectiveness results of the complete case analysis were similar to the multiple imputation analysis (Figure not shown).

DISCUSSION

Principal findings

The present study evaluated the cost-effectiveness of an unsupervised home-based proprioceptive training programme aimed at the prevention of ankle sprain recurrences, to be used after treatment by usual care in comparison with usual care alone. The present study showed that the marginal benefits associated with the intervention (the programme saved €103 per athlete) substantially exceeded the marginal cost of the intervention (€27.50 per athlete). This made the net benefit per athlete €75.50. This proprioceptive training programme showed significant lower costs of €103 per athlete and €332 per injured athlete in favour of the intervention group on top of a significant favourable effect on ankle sprain incidence.[11]

Strengths and weaknesses of the study

For several reasons, the present study presented multiple imputation data as primary data instead of data on complete cases. First, as complete-case analysis is considered reasonable if a small percentage of data are missing[3], the use of multiple imputation was warranted given that the proportion of missing data in the present study was about 25%. Furthermore, complete-case analysis is considered inefficient[3] and could lead to invalid results if the excluded group is a selective sub-sample (non-random sample) from the original study population (selective drop-out). Another drawback of complete-case analysis is that the power of the analysis is reduced. On the other hand, multiple imputation is an efficient method that accounts for uncertainty caused by missing data and provides correct statistical inferences.[22] In the present study, multiple imputation replaces each missing value by five imputations, leading to a small spread between the imputed values and resulting in low uncertainty about the missing data.

Table 4 Absolute numbers and accumulated costs (€) per category of utilisation of health care resources and absenteeism from work, and total costs (€) per group. Data are based on information derived from completed cost diaries only.

	Intervention (n=42)		Control (n=66)	
Type of utilisation	**Amount**	**Costs**	**Amount**	**Costs**
Health care costs:				
General practice (# of visits)	-	-	6	128.16
General practice (# of phone consults)	1	10.68	3	32.04
Physiotherapist (# of visits)	10	240.60	101	2,430.06
Sports physician (# of visits)	3	204.51	1	68.17
Medical specialist (# of visits)	1	71.92	5	359.60
Emergency room (# of visits)	1	147.01	3	441.03
Drugs		20.00		44.00
Medical devices				
Tape (# of rolls)	2	7.64	8	30.56
Brace	1	86.49	10	864.90
Subtotal		788.85		4,398.52
Costs of productivity loss:				
Absenteeism from paid work (days)	3	103.92	85	22,402.71
Absenteeism from unpaid work (hours)	163	1,431.14	863	7,577.14
Subtotal		1,535.06		29,979.85
Total costs		2,323.91		34,378.37

Since the randomization procedure resulted in equal groups in terms of sports exposure[11], no correction for exposure was necessary in the cost-effectiveness analysis. Although sports injury outcomes are preferably presented in incidence densities, clinical relevance of such numbers is not meaningful in cost-effectiveness analysis. The analysis presented in the present study provided clinically relevant outcomes by presenting costs per athlete and costs per injured athlete. In contrast, total costs to prevent, for example, 0.5 injuries per 1,000 hours of sports, as denominated when cost-effectiveness is expressed by incidence densities, is not considered clinically relevant.

The present study used self-report as a means of injury registration and cost registration. Since ankle sprain recurrences were reported on a monthly basis, recall bias was not very likely. However, misclassifications of injuries (i.e. faulty diagnosis of acute lateral ankle ligament sprains) sustained during the follow-up was possible. To minimize misclassification errors, registration forms were adapted forms recently used in a randomized trial in which self-report was used for the registration of ankle injuries and costs following these injuries.[30] In this latter trial, all recorded injuries to the ankle were blinded for group assignment and independently diagnosed by two physicians as being acute lateral ankle ligament sprains or other ankle injuries. Both physicians agreed on all injuries. Furthermore, the structure of registering injuries by self-report was comparable to a recent cluster-randomized controlled trial on the prevention of injuries in young female footballers.[23]

Differences are mainly caused by the difference in number of re-injuries and re-injury severity between groups. A total of 23 athletes in the control group were responsible for the 101 physiotherapy visits (range from 2 to 9 visits). In contrast, the 10 physiotherapy visits in the intervention group were done by 5 athletes. Physiotherapy visits do not contribute to the right-skewed cost data, which was mainly caused by a wide variation in sick leave.

Relation to other studies

The present study is the second to present an economic evaluation of a proprioceptive training programme. A recent study on proprioceptive balance board training in high-level volleyball players concluded that a season-long programme could be cost-effective in the long-term.[31] The present study is the first to show that an eight-week training programme is sufficient to significantly reduce ankle sprain recurrence risk[11], but also shows that health care costs and lost productivity costs due to ankle sprain recurrences can be reduced in comparison with usual care alone within a year after introduction of the intervention.

The importance of measuring costs due to productivity loss was shown in the economic evaluation in volleyball[31], in which 80% of all costs were caused by costs due to absenteeism from work. The present study showed even higher figures. A total of 86% of all costs per injured control group athlete were costs due to absenteeism from work. In contrast, 73% of all costs per injured intervention group athlete were indirect costs. It seems as if the effect on productivity loss is larger in the intervention group than in the control group.

Implications from a public health perspective

With an estimated 234,000 annual ankle sprains requiring medical treatment[32], in the Netherlands an estimated annual €24,102,000 in costs can be potentially saved solely by conducting a proprioceptive training programme as an adjunct following usual care. These costs-savings are likely not only to apply in the Netherlands, but are probably broadly applicable. Because medical costs in the United States are not comparable to the Dutch situation, it is not possible to estimate potential medical savings for the US. Next to differences in medical costs, differences in compensation of lost productivity costs can exist between countries.

Compensation costs in the Netherlands, where short term sick leave is covered for 100%, is different from other countries, making sick leave compensation, as well as duration different and, therefore, indirect costs substantially lower in those countries and maybe even negligible.
This training programme has the potential to lead to substantial savings in medical and lost productivity costs. An important step would be to integrate this programme in the current ruling clinical guidelines on the treatment of ankle sprains. Since the intervention was largely web-based, implementation through digital channels is recommended.

What is already known on this topic

Ankle sprain is one of the most common and costly sports injury
Dutch annual sports related ankle sprain costs can roughly be estimated at €84,200,000
Cost-effectiveness analyses are scarce in the field of sports injury prevention

What this study adds

In the Netherlands an estimated annual €24,102,000 in costs can be potentially saved solely by conducting a proprioceptive training programme as an adjunct following usual care
Costs-savings are likely not only to apply in the Netherlands, but are probably broadly applicable
The presented cost savings after the introduction of an easy to perform exercise programme, warrant implementation of this programme

CONCLUSIONS

This economic evaluation alongside a randomized controlled trial showed that the use of a proprioceptive training programme after usual care of an ankle sprain is cost-effective for the prevention of ankle sprain recurrences in comparison with usual care alone. Furthermore, the cost savings presented in this study warrant implementation of this proprioceptive training programme.

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