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Physical exercise through mountain hiking in high-risk suicide patients. A randomized crossover trial

Sturm J, Plöderl M, Fartacek C, Kralovec K, Neunhäuserer D, Niederseer D, Hitzl W, Niebauer J, Schiepek G, Fartacek R. Physical exercise through mountain hiking in high-risk suicide patients. A randomized crossover trial.

Objective: The following crossover pilot study attempts to prove the effects of endurance training through mountain hiking in high-risk suicide patients.
Method: Participants ($n = 20$) having attempted suicide at least once and clinically diagnosed with hopelessness were randomly distributed among two groups. Group 1 ($n = 10$) began with a 9-week hiking phase followed by a 9-week control phase. Group 2 ($n = 10$) worked vice versa. Assessments included the Beck Hopelessness Scale (BHS), Beck Depression Inventory (BDI), Beck Scale of Suicide Ideation (BSI), and maximum physical endurance.
Results: Ten participants of Group 1 and seven participants of Group 2 completed the study. A comparison between conditions showed that, in the hiking phase, there was a significant decrease in hopelessness ($P < 0.0001$, $d = -1.4$) and depression ($P < 0.0001$, $d = -1.38$), and a significant increase in physical endurance ($P < 0.0001$, $d = 1.0$), but no significant effect for suicide ideation ($P = 0.25$, $d = -0.29$). However, within the hiking phase, there was a significant decrease in suicide ideation ($P = 0.005$, $d = -0.79$).
Conclusion: The results suggest that a group experience of regular monitored mountain hiking, organized as an add-on therapy to usual care, is associated with an improvement of hopelessness, depression, and suicide ideation in patients suffering from high-level suicide risk.

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Key words: physical exercise; hopelessness; depression; suicide ideation

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Significant Outcomes

- Regular endurance training in form of mountain hiking for high-level suicide risk patients can provide an effective means of reducing hopelessness, depression, and suicide ideation.
- Mountain hiking can be an effective add-on therapy with significant additive effects in conjunction with psychotherapeutic and psychopharmacological treatment.
- High-risk suicide patients in our study were able to be motivated to participate in regular mountain hiking. They demonstrated high-level compliance and were capable of significantly increasing physical endurance levels.

Limitations

- The present study is a pilot study with only a small sample. The results, however, are statistically significant.
- Selection bias cannot be entirely excluded as participants volunteered for the study. Still, no connection between treatment expectation at the beginning of the study and treatment outcome was ascertainable.
- The observed effects cannot be exclusively attributed to physical exercise and increased endurance. Social backup, treatment expectations, experiencing nature as well as other yet unknown factors must be credited as well.

Introduction

Suicide presents a substantial social problem. Annually, an estimated 1 million people kill themselves worldwide and 10–20 million more attempt suicide in the course of a year (1). Attempted previous suicide is considered a risk factor with a 30-fold increase in risk of future suicide attempts and suicide (2). In addition to diseases such as mood disorders, borderline personality disorder, disruptive behavior disorders, alcohol and drug abuse disorders, anxiety disorders, anorexia nervosa, and schizophrenia, all of which show a clearly proven relationship to suicide (3), hopelessness, depression, and suicide ideation are among the most significant cross-disease mental risk factors (4, 5). Hopelessness is considered to be one of the most significant long-term suicide risk factors (3) and is definable as a system of cognitive schemas based on negative expectations for the future (6). A meta-analysis of 10 follow-up studies has shown that people with clinically relevant hopelessness show a 3.4-fold higher risk of committing suicide (7).

The effective treatment of mental disorders and risk factors such as hopelessness, depression, and suicide ideation is the primary treatment goal of suicide prevention. Here, standard therapy consists of psychopharmacological antidepressants and, psychotherapeutically, cognitive behavioral therapy (8, 9). In addition, effective suicide prevention strategies consist of promoting preventative factors and resources within suicide-risk patients. Such protective factors include increasing physical health, hopefulness, cognitive flexibility, coping skills, social support as well as prevention and timely treatment of mental disorders (10).

A review of 28 randomized controlled studies shows the great therapeutic effect of physical exercise in patients with depression disorders (11); however, the methodological quality of these studies is questionable. Exercise appears to show similar results as antidepressants (12); however, exercise can show lower recidivism rates (13) and appears to be more useful for long-term treatment in reducing depression symptoms (14) as well as in treatment-resistant patients with major depressive disorder (15). Several studies have established comparative effects with cognitive behavioral therapy (16), and one study shows a dose-effect relationship proving that exercise requires a certain number of training sessions before it proves useful in reducing depression symptoms (17).

Exercise and sports might also be preventative factors in suicide attempts and suicide. A number of cross-sectional studies with students (ages 11–25) and one study with military recruits have shown that regular participation in athletic activity is associated with a reduction in hopelessness, depression, suicide ideation, attempted suicide, and suicide (18–29). One case–control study with 13- to 34-year-olds provides evidence of physical inactivity as a risk factor for suicide attempts: One month before attempting suicide, attempters had been significantly less physically active than the reference group (25).

Hiking could provide an appropriate return to physical activity for people at risk of committing suicide, because they can be monitored in a way as to avoid over-exertion, at the same time offering positive effects through moderate endurance training as well as positive outdoor experiences and relationships among the hiking group.

Aims of the study

The aim of our study was to investigate the efficacy of therapeutic endurance training during mountain hiking with a group of high-risk suicide patients with a view to reducing suicide risk. Pertinent measurement parameters for assessing suicide risk were hopelessness, depression, and suicide ideation.

Material and methods

Design and procedures

This intervention study employed a randomized, controlled crossover design (Fig. 1). Crossover design was used for ethical reasons to allow each

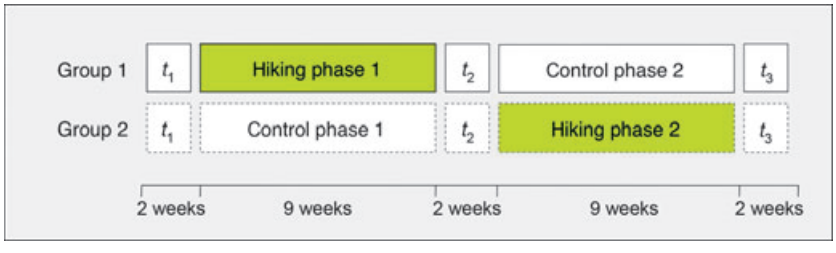

Fig. 1. Crossover design (t1–t3 = examination dates; entire length of study = 24 weeks; t1 = 2 weeks; hiking phase 1 = 9 weeks; t2 = 2 weeks; hiking phase 2 = 9 weeks; t3 = 2 weeks).

participant access to this intervention and, on the other hand, to increase analysis power. Our study was approved by the City of Salzburg's Ethic Commission, and all participants signed a Participant Release form. Sample size was calculated using G-Power 3.1 and in agreement with the results of previous studies (30, 31) for an effect size of 0.8. A total of 15 participants were required to detect a reduction in Beck Hopelessness Scale (BHS) for the specified effect size with a power of 90% (two-sided, paired *t*-test at a significance level of 5%). Assuming a drop-out rate of 30%, the sample size was adjusted to 20 patients.

Hundred and sixty-seven patients with a history of at least one suicide attempt were contacted via mail and invited to attend an informal meeting. Thirty-one patients attended, and 23 patients (15 women, seven men) agreed to participate in the initial assessment. Inclusion criteria were a high suicide risk (defined as at least one reported previous suicide attempt) and a current BHS sum score of >26. Additional inclusion criteria were living no more than 50 km away from Salzburg (the place of the study) and a minimum age of 18. Exclusion criteria were coronary heart disease (myocardial infarction during the last 6 months or angina pectoris or relevant ECG changes during stress testing), cognitive impairments, and insufficient German skills.

After initial assessments, one patient was excluded for a current BHS below 27, another patient because of arthrosis of the knee joint and one patient because of pending heart surgery. Immediately after the initial assessment, randomization was performed using random numbers. To guarantee a balanced design, stratified randomization was used to divide our sample into two similar groups (Fig. 2). Gender was used as strata. Each group consisted of 10 participants (three men, seven women). Until the start of hiking phase 1, neither the participants nor the researchers who did the first assessments were aware of which participants were allocated to which group to ensure concealment of allocation. The generation of the computer-generated list of random numbers and allocation concealment was carried out by a mathematician who was not involved in the study. The participants were informed about the group they belonged to directly before hiking phase 1 by the director of the study.

All participants had been in inpatient care at the Psychiatric University Clinic before the study. Their mental disorders were diagnosed according to ICD-10 as follows: In Group 1, six participants had been diagnosed with recurrent major depressive disorders (F33), two participants with comorbid alcoholism (F10), one with a comorbid emotionally unstable personality disorder (F60.3). The remaining four patients were suffering from bipolar disorder (F31.3), another from schizoaffective disorder (F25.1), another from emotional unstable personality disorder (F60.3) and another one from adjustment disorder (F43.2) with comorbid alcoholism (F10.2). In Group 2, four patients

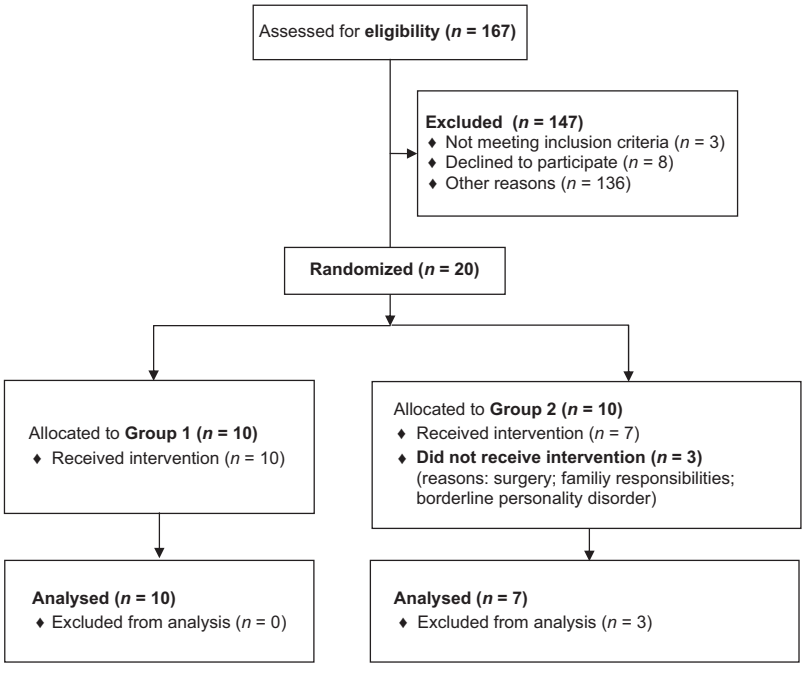

Fig. 2. Participant flow throughout the trial.

had a recurrent depressive disorder (F33), one with comorbid alcoholism (F10.2), and one with comorbid sedative abuse (F13.1). The remaining three patients suffered one from an emotionally unstable personality disorder (F60.3), one from a moderate depressive episode (F32.1), and one from anxiety and depression mixed (F41.2).

Assessment

Hopelessness was measured with the Beck Hopelessness Scale (6); depression with the Beck Depression Inventory, 2nd edition (32); suicide ideation with the Beck Scale for Suicide Ideation (33); sense of belonging according to the German quality-of-life questionnaire '*Profil der Lebensqualität chronisch Kranker*' (34); treatment expectation with one item 'How much do you trust that participating in this hiking study will help you solve your problems?', which was measured by a visual analog scale (0–100: no trust–total trust). Maximum endurance was tested through cycle ergometer stress tests. The protocol provided an initial workload of 20 watts for women and 50 watts for men, with 10-watt increment per minute until workout load was reached. Measurement parameters for determining endurance were maximum wattage per kilogram of bodyweight (watts/kg). Individual ranges for recommended exercise heart rate (REHr) were calculated from the resting heart rate (RHr) and the maximum heart rate (HRmax) by applying the Karvonen formula (REHr = (HRmax − RHr) × Factor + RHr). Factor 0.65 was the lower-end and 0.75 the upper-end heart rate (35).

Three measurement dates were set: before hiking phase 1, in between the hiking phases and after hiking phase 2 (Fig. 1). Assessments were performed by independent researchers who did not participate in the hiking program. In the initial assessment, those who made the assessments did not know which participant belonged to which group because the participants did not know as well. In the further assessments, those who made the assessments were possibly aware of which participant belonged to which group, because patients sometimes talked to them during the assessments. Owing to the nature of the intervention, it was not possible to perform blinding for participants. All initial psychological assessments were performed at the Psychiatric University Clinic. Sport medical examinations were performed at the University Institute of Sports Medicine, Prevention and Rehabilitation, Paracelsus Medical University Salzburg. Self-assessment questionnaires were answered online. Participants were cautioned to answer questionnaires alone, honestly, and to take their time.

The entire study lasted 24 weeks. Nine weeks per hiking phase and a period of 2 weeks for each assessment to arrange dates for all examinations and participants. We did not arrange a wash-out phase with two assessments during the hiking phases because of practical reasons. It would have prolonged the study into winter, which would have caused the risk of having snow and ice during hiking phase 2. Also, it would have been an additional burden for the participants, and it would not have been possible to schedule all examination dates in regard to our resources.

Mountain hiking program

During Phase 1 of the study, members from Group 1 ($n = 10$) took part in a 9-week hiking program, while members from Group 2 ($n = 10$) received no intervention. During Phase 2, members from Group 2 ($n = 7$) took part in a 9-week hiking program, while members from Group 1 ($n = 10$) received no intervention (Fig. 1).

Interventions consisted of a 9-week monitored hiking program. Three hikes (on Mondays, Wednesdays and Fridays) were offered each week. Participants were invited to participate at least twice per week. Each hike lasted 2–3 h and occurred at an intensity of 65–75% according to the Karvonen formula (35). Training intensity was controlled during the hikes with the help of heart rate monitors. Warm-up exercises were offered before the hikes and stretching exercises were offered at the end of the hikes. Each hike was lead by two persons in charge, that is, the director of the study and one additional person such as a nurse, a psychotherapist, or a physician. Hikes were at different locations. Criteria were altitude differences of 300–500 m in elevation gain, a hiking period of 2–3 h, a simple to moderate level of difficulty, and a maximum traveling time from Salzburg of no more than 30–45 min to the hiking location, which was done as group by bus.

In the control phase, the participants were not given special guidelines other than what they would be normally doing, in addition to their usual psychopharmacological and psychotherapeutic therapy.

Statistical analyses

Aim of the statistical analyses was to compare outcome measures before and after the hiking phase and before and after the control phase. In crossover analyses, Group 1 and Group 2 were

merged ($n = 17$) to better illustrate the combined effects for the hiking and control phase. In single subject analysis, analyses for Group 1 ($n = 10$) and Group 2 ($n = 7$) were carried out individually to show any differences between both groups.

For assessing the difference between the baseline characteristics of both groups, an independent samples *t*-test and a Fisher's exact test were performed. For assessing the difference between dependent variables Beck Hopelessness Scale (BHS), Beck Depression Inventory (BDI), Beck Scale of Suicide Ideation (BSI), sense of belonging and physical endurance before and after the hiking phase and before and after the control phase, paired *t*-tests were applied. To compute effect sizes, we used Cohen's *d* (36) for paired *t*-tests. For assessing correlations between changes in dependent variables BHS, BDI, BSI, and physical endurance as compared to independent variables of treatment expectation, and the number of hikes, Pearson's product-moment correlations were calculated.

For all statistical analyses, a *P*-value of < 0.05 was determined as statistically significant. Microsoft Excel 2008 for Mac, Redmond, WA, USA, was used for data preparation and graphics. All statistical analyses were performed with SPSS 13.0 for Windows, SPSS Inc., Chicago, IL, USA.

Results

Eligible participants were recruited for the study between June and July 2010. Twenty participants were randomized and included in the study but only 10 participants of Group 1 and seven participants of Group 2 completed the clinical trial (Fig. 2). During the second assessment, two participants of Group 2 dropped out: One patient because of complications after shoulder surgery and one patient because the hikes would have been too much of a strain on her family responsibilities. Another participant of Group 2 dropped out after the first hike because his borderline personality disorder made it impossible for him to get along with the rest of the group. It was not possible to conduct an intention to treat analyses, because the three dropouts were not present for final assessments.

Baseline characteristics are shown in Table 1. At the onset of the study and the hiking phases, no significant differences in age, sex, number of previously attempted suicides, bodyweight, BMI, BHS, BDI, BSI, physical endurance, sense of belonging, and treatment expectations were observed between both groups. Members of Group 1 ($n = 10$) participated in 12–26-day hikes ($M = 18.2 \pm SD = 5.0$), those of Group 2 ($n = 7$) participated in 14–24-day hikes ($M = 18.6 \pm SD = 4.1$). No significant difference in the number of hikes was observed between the groups ($P = 0.81$). Just completers of the hiking program were counted for comparing number of hikes.

Table 1. Baseline characteristics in Group 1 and Group 2 in mean ± SD; significance at $P < 0.05$

	Group 1 ($n = 10$)	Group 2 ($n = 10$)	*P*
Age (years)	45.1 ± 10.4	41.0 ± 6.3	0.30
Sex ratio (M:F)	3 : 7	3 : 7	1.0
Previous suicide attempts			
One suicide attempt	3 (30%)	5 (50%)	0.65
Two/more suicide attempts	7 (70%)	5 (50%)	
Body weight (kg)	80.6 ± 15.8	72.8 ± 13.7	0.26
Body mass index (kg/m^2)	27.8 ± 5.8	25.8 ± 4.6	0.41
BHS	31.9 ± 4.7	31.2 ± 4.0	0.85
BDI	27.4 ± 12.5	28.3 ± 9.9	0.86
BSI	11.0 ± 8.2	14.9 ± 7.8	0.27
Watts/kg	1.9 ± 0.5	2.0 ± 0.6	0.50
Sense of belonging	2.3 ± 0.8	2.0 ± 1.0	0.49
Treatment expectation	74.2 ± 15.5	62.4 ± 33.2	0.32

BHS, Beck Hopelessness Scale; BDI, Beck Depression Inventory; BSI, Beck Scale of Suicide Ideation.

At baseline, all participants indicated at least one attempted suicide (Table 1, BSI item 20). Concerning the wish to die (BSI item 21) at the last suicide attempt, two, participants of Group 1 indicated a moderate wish to die and eight participants a strong wish to die. In Group 2, three participants indicated a slight wish to die, two participants a moderate wish to die, and five participants a strong wish to die. During the entire study, participants continued their regular usual regimen of psychotherapy sessions (Group 1 received mean $= 2.8 \pm SD = 2.0$ h/month and Group 2 mean $= 2.9 \pm SD = 1.7$ h/month) as well as psychopharmacological treatment. Eight members of Group 1 received psychotherapeutic as well as psychopharmacological treatment, and two members received only psychopharmacological treatment. In Group 2, five members received psychotherapeutic as well as psychopharmacological treatment, one member received only psychotherapy, and one member only psychopharmacological treatment.

Crossover analysis (Table 2) shows a significant reduction in hopelessness, depression, and suicide ideation during the hiking phase as well as a significant increase in sense of belonging and physical endurance. During the control phase there was no significant change in these variables with the exception of a significant increase in depression. Individual analysis (Fig. 3) of both groups shows similar results; however, during the

Table 2. Crossover evaluation for hiking and control phase of both groups (intervention and control phases for both groups combined); PRE/POST in mean ± SD; Δ in mean difference with 95% CI, confidence interval; *significance at $P < 0.05$; †For Cohen's *d*, an effect size of 0.2–0.3 might be a small effect, around 0.5 a medium effect, and 0.8 to infinity a large effect

	Hiking phase ($n = 17$)							Control phase ($n = 17$)							Δ Hiking vs. Δ control	
	PRE	POST	Δ	(±95% CI)		P	d†	PRE	POST	Δ	(±95% CI)		P	d†	P	d†
BHS	31 ± 5	26 ± 5	−5.3	−6.7	−3.9	<0.0001*	−1.95	28 ± 5	29 ± 5	1	−0.35	2.35	0.135	0.38	<0.0001*	−1.4
BDI	27 ± 11	14 ± 11	−13	−17.5	−8.5	<0.0001*	−1.5	19 ± 14	23 ± 12	3.5	0.18	6.88	0.040*	0.54	<0.0001*	−1.38
BSI	10 ± 8	6 ± 8	−4.4	−7.2	−1.5	0.005*	−0.79	10 ± 9	8 ± 8	−1.8	−4.80	−1.14	0.212	−0.32	0.25	−0.29
Watts/kg	1.9 ± 0.5	2.2 ± 0.5	0.3	0.18	0.33	<0.0001*	0.59	2.1 ± 0.5	2.0 ± 0.4	−0.1	−0.20	0.05	0.250	−0.26	<0.0001*	1.00
Sense of belonging	2.2 ± 0.9	2.8 ± 0.8	0.6	0.08	1.1	0.03*	1.76	2.3 ± 1	2.1 ± 0.9	−0.3	−0.76	0.24	0.292	−0.29	0.04*	0.53
Treatment expectation	72 ± 19	81 ± 22	9.6	0.22	19.0	0.05*	0.53	76 ± 23	74 ± 24	−2.4	−9.0	4.3	0.462	−0.18	0.04*	0.48

BHS, Beck Hopelessness Scale; BDI, Beck Depression Inventory; BSI, Beck Scale of Suicide Ideation.

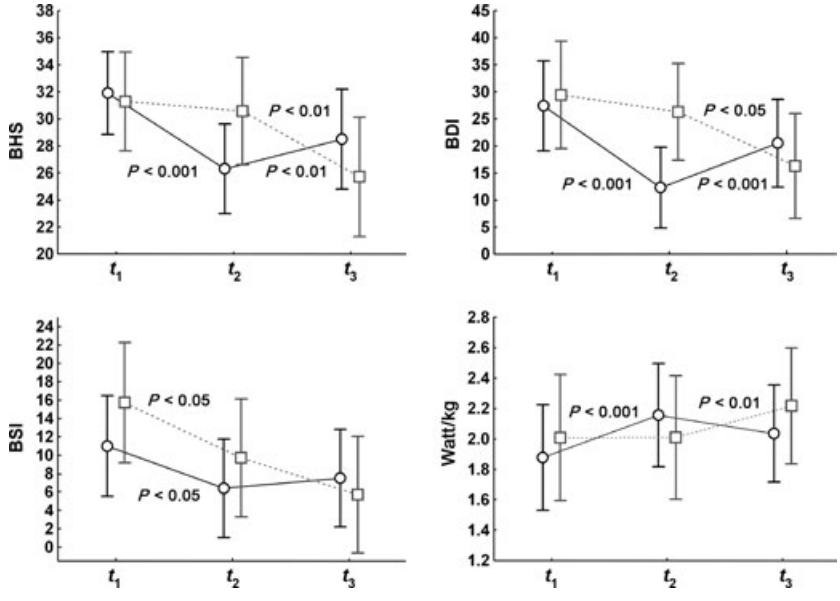

Fig. 3. Results of individual group analysis (line diagram: solid line = Group 1; dotted line = Group 2); representation of the mean and confidence intervals (±2× SE); significance at $P < 0.05$.

hiking phase, sense of belonging did not reach a statistically significant level, neither did suicide ideation in Group 2. During the control phase, hopelessness and depression among Group 1 members increased significantly, whereas suicide ideation decreased significantly in Group 2. The fact that suicide ideation in Group 2 decreased significantly in the control phase but not in the hiking phase can be associated with statistical outliers. Three patients showed an extremely high sum score for suicide ideation at the initial examination, which was considerably reduced after the control phase and even more during the hiking phase. The parameters of hopelessness and depression, however, did not significantly change for these three participants in the control phase.

The number of hikes showed no significant relationship to changes in BHS ($r = 0.28$, $P = 0.27$), BDI ($r = 0.33$, $P = 0.20$), BSI ($r = -0.16$, $P = 0.53$), and physical endurance ($r = -0.17$, $P = 0.51$). Also, no significant relationship between treatment expectation at the onset of the study and changes in BHS ($r = -0.12$, $P = 0.64$), BDI ($r = -0.1$, $P = 0.70$), BSI ($r = 0.22$, $P = 0.4$), and physical endurance ($r = -0.42$, $P = 0.09$) was observed.

Discussion

Numerous studies have shown that hopelessness, depression, and suicide ideation are significant risk factors for suicide (4, 7). Reducing these risk factors is an important treatment goal in suicide prevention (8). Cross-sectional studies as well as case-control studies point toward the fact that physical exercise is inversely associated with

hopelessness, depression, and suicide ideation (18, 20, 25). Aim of our study was to investigate whether regular exercise training in form of mountain hiking might reduce risk factors mentioned earlier in high-risk suicide patients.

The results of our study suggest that regular endurance training through mountain hiking can be an effective means of reducing such risk factors as hopelessness, depression, and suicide ideation in high-risk suicide patients. In addition, our findings show that high-risk suicide patients can become very motivated to participate in mountain hiking and can show a high level of compliance with this form of treatment. This is demonstrated by the fact that all participants but one who started with the hiking program also finished the program. It is noteworthy that participants had to sacrifice a considerable amount of time to participate in the hikes as well as the screenings and examinations. Two of the three participants who dropped out of Group 2 dropped out during assessment 2 before the hiking phase 2 for reasons making it impossible for them to participate (surgery, family). The third participant dropped out after the first hike of hiking phase 2 because he found it impossible to participate in a group intervention such as this because of his borderline personality disorder. Therefore, he dropped out by mutual agreement. Moreover the results demonstrate that high-risk suicide patients can improve their physical endurance through regular mountain hiking.

The results of our study agree with numerous other studies supporting the efficacy of physical endurance training in reducing depression (11) and, for the first time, also show this effect in high-risk suicide patients. The results indicate that regular monitored mountain hiking can be a useful form of add-on therapy in reducing depression in high-risk suicide patients. In addition, the results of our study are consistent with cross-sectional studies that demonstrate a relationship between physical exercise and reduced hopelessness, depression, and suicide ideation in adolescents (18, 20) and demonstrate this effect during mountain hiking in a randomized controlled crossover design with a larger age-group and population segment. The less consistent results concerning suicide ideation in Group 2 can be traced to three statistical outliers as described earlier in the results. The fact that effects in Group 1 were largely lost after the control phase (Fig. 3) is difficult to explain other than by the assumption that the effects can be expected just while exercising regularly.

At the present time, standard forms of therapy for treating hopelessness in high-risk suicide patients are psychopharmacological treatment and psychotherapy. The efficacy of psychotherapy in reducing hopelessness in suicidal patients has been empirically tested and proven for problem solving therapy (PST), cognitive behavioral therapy (CBT), and dialectical behavior therapy (DBT) (30, 31). Ours was the first study to investigate and prove the efficacy of endurance training through monitored mountain hiking for the purpose of reducing hopelessness in high-risk suicide patients. It is not self-evident and implicit that health-promoting activities such as mountain hiking would prove to be salutary in high-risk patients, as a study investigating school health programs also showed negative effects in adolescents at risk (37).

The effects shown in our study clearly go beyond the effects of existing psychopharmacological as well as psychotherapeutic treatment because the participants of our study had previously been in psychotherapy for a number of years. They had also received psychiatric/psychopharmacological treatment and their standard treatment regimen continued on during the course of the study, showing that mountain hiking on a regular basis can offer additional benefits on top of standard forms of therapy. Reduction in BHS of this study is comparable with effects from psychotherapy studies (30, 38), thus underscoring the significance of our study's results.

Cross-sectional studies show that physical exercise is not *per se* or directly related to suicide risk; instead, it is influenced by certain mechanisms such as physical activity, heightened self-esteem and social support (18, 26, 39). A cross-sectional study with 14 000 students has shown that even after taking into consideration such influencing factors as self-esteem and social support, an inverse relationship between physical activity and suicide ideation remains (18). A systematic review of eleven trials (40) which investigated the effects on mental wellbeing through participation in physical activity in natural environments compared with physical activity indoors showed that exercising in nature was associated with a greater decrease in depression, a greater enjoyment and satisfaction and a greater intent to repeat the activity in comparison with exercising indoor. However, these findings must be interpreted with caution because of the poor methodological quality of the studies and the heterogeneity of outcome measures considered.

Limitations

Several limitations must be taken into consideration when interpreting our study's results. Firstly,

this study was a pilot study with a small sample size. Therefore, it must be stressed all the more that the effects were large enough to reach a statistically significant level. Secondly, a selection bias cannot be ruled out, because participants volunteered for this study, which means that no statement can be made concerning the question whether mountain hiking would produce similar results in other patients that were contacted via mail. No significant relationship between treatment expectation at the beginning of the study and changes in BHS, BDI, or BSI were observable in this sample. Thirdly, no intention-to-treat analysis was able to be performed because those three participants who dropped out of Group 2 did not participate in the concluding examinations. This might have skewed the results. Fourthly, blinding was not performed for those who made the assessments.

Fifthly, the study's observable effects cannot be attributed exclusively to physical exercise. Treatment expectations, social support, being exposed to the outdoors as well as other factors were not entirely controllable owing to the intervention's holistic nature and the small sample size. The intervention's specific action mechanisms were not determinable by means of the study's present design. Other studies using control groups exposed to group intervention without endurance exercise (stretching, health education) or a home-exercise group that exercised on its own did, however, show that exercise training for reducing symptoms of depression is significantly more therapeutic than social support alone and that significant effects arise even without any social support at all (17, 41, 42). To enhance participation in physical activity programs, it has been pointed out that social components should be included for people with mental illnesses (43). In contrast, crossover analysis of our study showed that sense of belonging significantly improved during the hiking phase as compared to the control phase. However, the effect was not enough to reach a significant level in individual analysis. Sixthly, the drawback of not having a proper wash-out phase in between hiking phases has to be discussed. A negative aspect might have been if Group 1 would not have changed into a true control group, which would have confounded the intervention effects. In our study, the treatment effects were mainly lost after the control phase in Group 1, which suggests that the control phase was sufficiently long. Another, possibly more important aspect is that values from treatment outcomes are the same as values at the beginning of the control phase that leads to the impression that parameters worsened during the control phase in Group 1.

Perspectives

We recommend repeating this study with a larger sample and focusing on psychological and physiological action mechanisms. In terms of a larger study, a parallel design might be more favorable to overcome the drawbacks of a crossover design. Blinding for those who made the assessments would be a desirable improvement for a future trial. Regular endurance exercise training through monitored mountain hiking with its medium to large effects as well as its positive physical side effects could become an effective complement to current standard therapies of psychopharmacology and psychotherapy in suicide prevention.

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