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Randomized trial of physical exercise alone or combined with bright light on mood and health-related quality of life

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ABSTRACT

Background. So-called atypical depressive symptoms (carbohydrate craving, prolonged sleep, weight gain, increased appetite) frequently emerge in association with low illumination to which people are ordinarily exposed indoors, or even outdoors at extreme latitudes in wintertime. Our objective was to analyse the effect of physical exercise alone or combined with bright light on mood and the health-related quality of life during winter.

Methods. We carried out a randomized controlled trial on 120 indoor employees in southern Finland between November and January. The subjects were allocated to supervised fitness training under bright (2500–4000 lx) or ordinary (400–600 lx) light conditions in a gym 2–3 times weekly for 8 weeks, or supervised relaxation training once a week over the same period as active placebo. We collected questionnaire data on the changes in mood and health-related quality of life after 4 and 8 weeks of training, and after 4 months follow-up.

Results. Fitness training in bright light resulted in greater relief from atypical depressive symptoms and more vitality than in ordinary room light. Compared with relaxation alone, the former regime improved general mental health and social functioning in addition to the improvement in depressive symptoms and vitality, whereas the latter only increased vitality.

Conclusions. Supervised physical exercise combined with exposure to bright light appears to be an effective intervention for improving mood and certain aspects of the health-related quality of life in wintertime. This effect appears unrelated to the history of season-dependent symptoms, being noticeable among healthy individuals.

INTRODUCTION

Seasonal changes in mood and behaviour are frequent in the general population (Schlager *et al.* 1995). Ten to 15% of primary care patients in industrialized countries routinely complain of symptoms experienced during winter (Schlager *et al.* 1993). So-called atypical depressive symptoms (carbohydrate craving, prolonged sleep, weight gain, increased appetite) frequently emerge in association with low illumination to which people are ordinarily exposed indoors (Espiritu *et al.* 1994), or even outdoors at extreme latitudes in wintertime. Earlier studies suggested that depressive symptoms could be well-treated with physical exercise (Martinsen *et al.* 1989) and seasonal pattern, in particular, with exposure to bright light (Kasper *et al.* 1989). Our objective was to study the effect of fitness training alone, or combined with bright light, on mood and the health-related quality of life experienced by healthy employees in winter.

METHOD

We enrolled subjects from the employees of five workplaces, yielding a target population of approximately 15000 persons. We provided

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information about the protocol to the staff of the occupational health care centre of each company in a face-to-face meeting. A leaflet was delivered to all employees by the staff of their centre, which they were advised to contact for further information. The covering letter invited especially those healthy subjects who routinely suffered from some difficulties during winter to take part in a trial focusing on the effect of supervised physical exercise. The administration of bright light was not mentioned. Our target population comprised healthy subjects with or without subsyndromal seasonal affective disorder (SAD). The exclusion criteria were progressive eye disease, severe general medical conditions, which could have jeopardized physical exercise, and severe psychiatric disorders requiring specialist attention. The chief physician at each centre gave the second opinion about the eligibility of each subject. All the participants were working while engaged in the study, and none was taking psychotropic medication. The trial was carried out between 25 November 1996 and 25 January 1997.

The 120 eligible subjects were randomized into either fitness training in bright (2500–4000 lx) light (group A), fitness training in ordinary (400–600 lx) room light (group B), or relaxation training (group C). Those subjects assigned to groups A and B were first assessed using a five-part series of fitness tests which primarily measured the endurance and flexibility of the back muscles. On the basis of the test results, a fitness training programme was tailored for each individual, aimed at strenuous aerobic exercise using special equipment for systematic training of major muscle groups. The fitness training took place in a gym for 1 hour twice or three times a week for 8 weeks. The compliance was checked by the physiotherapist once a week. The fitness tests were repeated after 8 weeks of intervention. Those subjects assigned to group C took part in relaxation sessions supervised by another physiotherapist and undertaken in a dimly lit room next to the gym for 1 hour once a week. Each group attended their activities at separate times to avoid communication between the groups. We tried to ensure an equal sex ratio for each group at the beginning but desisted from the plan because of shortage of time.

Thirty extra light fixtures with cool-white (6000 K) fluorescent lamps (F58W/186, Sylvania, Germany) were fixed to the ceiling for the administration of bright light in the gym. For the group B subjects, the gym was normally lit with a regular number of similar lamps (F36W/186). The intensity of light was repeatedly measured at 100 cm above floor level after the lamps had warmed up. The subjects were asked to face the lights but not to look directly into them while engaged in training.

At baseline, subjects filled in the Seasonal Pattern Assessment Questionnaire (SPAQ; Rosenthal *et al.* 1987). The revised version of the Structured Interview Guide for the Hamilton Depression Rating Scale – Seasonal Affective Disorders Version Self-Rating Format (SIGH-SAD-SR; Williams *et al.* 1991) and the RAND 36-item Health Survey 1.0 (RAND; Hays *et al.* 1993) were delivered to the subjects to be filled in also at weeks 4 and 8 of intervention. At 4 months follow-up in May 1997, subjects were asked to fill in the RAND and the SIGH-SAD-SR. Non-responders received a follow-up letter, encouraging them to reply.

The SPAQ measures mood and behavioural changes with the seasons, and the sum of its 6-item scale gives the Global Seasonality Score (GSS). The SIGH-SAD-SR consists of the self-rated formats of the 21-item Hamilton Depression Rating Scale (HDRS) for scoring typical depressive symptoms and the 8-item addendum for scoring atypical depressive symptoms. The RAND generates eight dimensions of functioning and is sensitive to changes in health among general populations (Hemingway *et al.* 1997). All the questionnaires had been translated into Finnish and then back into English to verify their linguistic accuracy.

The SPAQ criteria for subsyndromal SAD require that subjects have a GSS of 10 or more and experience seasonal change as no more than a mild problem, or a GSS of 8 or 9 and experience seasonal change at as least a mild problem (Bartko & Kasper, 1989). Subjects with subsyndromal SAD regard themselves as normal, have no serious medical condition or history of major affective disorder in winter, but do routinely have a history of some difficulties during the winter months (Kasper *et al.* 1989). The SPAQ criteria for SAD require that subjects have a GSS of 10 or more and experience

seasonal change as a problem at least to a moderate degree. We challenged the SPAQ criteria and considered SAD with respect to clinical assessment only if subjects scored 19 or over on the HDRS of the SIGH-SAD-SR (Philipp *et al*. 1992).

Ethics

The study was approved by the ethics committee of the institution. All subjects gave their written informed consent to the participation.

Statistics

The calculation of the sample size was based on the expected reduction in atypical depressive symptoms measured on an interval scale. Our estimate of the standard deviation (5 points) on the 8-item addendum of the SIGH-SAD-SR was based on the results of an earlier study (Kasper *et al*. 1989). We accepted the risk of committing type I and type II errors of 5% each and were not willing to overlook the difference of 6 points between the means in the two groups (A and B). The minimum number of subjects required in each group was 18. Our setting used the absolute scores of the SIGH-SAD-SR and those of the RAND at week 8 as well as the changes in these scores as the outcome measures.

A separate general linear model using a general factorial analysis of variance was computed for each outcome measure with allowance for group and the pre-intervention baseline score as a covariate. The error variances were analysed using the Levene's test of equality. The overall test of an intervention effect was supplemented by using custom hypothesis tests with a simple contrast to test for effects of 'bright light' *v*. 'active placebo'. We compared the difference in absolute scores between the groups using the Mann–Whitney *U* test (each pair of groups) for the non-parametric data or the independent samples *t* test for the parametric data. The distributions were analysed using the Shapiro–Wilk test of normality. Associations between the variables were analysed by calculating partial correlation coefficients, which were controlled for the pre-intervention baseline score. The data were also evaluated by examining the mean and 95% confidence interval (95% Cl) of each outcome measure. Data of those three who had changed groups by giving erroneous information to the staff at the gym were excluded from analysis of the outcome variables.

RESULTS

Of the 120 subjects allocated, 115 (96%) entered the study (see Fig. 1). Of the 115 participants, 103 (90%) responded to at least one of the questionnaires. Their mean (S.D.) age was 39·4 (9·6) years (range 22 to 57) and 91 (88%) were women. The mean (S.D.) age of subjects was 39·8 (10·2), 38·6 (9·9) and 39·7 (9·1) years in groups A, B and C, respectively. There were 31 (86%), 28 (80%) and 28 (100%) women in groups A, B and C respectively. Of the 103 respondents, 82 (80%) completed the entire 8 weeks of the trial. Four of those 12 who withdrew without responding to the questionnaires did not start the training at all. Three of the 21 subjects who dropped out (all in group A) stopped the training because of side-effects: two due to pain induced by the exercise, and one owing to insomnia which she attributed to the bright-light exposure.

At follow-up, 78 (76%) of the questionnaires sent to the original 103 respondents were returned. We received complete data on 24

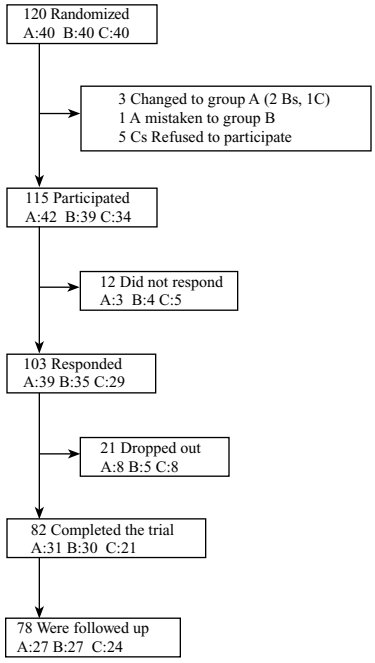

FIG. 1. Trial profile.

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Table 1. *Mean (S.D.) ratings by intervention group*

	At baseline			At week 8			At follow-up		
	Group A $N = 35$	Group B $N = 35$	Group C $N = 28$	Group A $N = 29$	Group B $N = 30$	Group C $N = 21$	Group A $N = 23$	Group B $N = 27$	Group C $N = 24$
SIGH-SAD-SR									
HDRS symptoms	12·2 (5·6)	10·9 (6·8)	9·8 (5·3)	4·5 (4·6)	6·2 (4·3)	8·6 (6·5)	6·9 (6·8)	5·7 (4·8)	6·0 (4·7)
Atypical symptoms	8·6 (5·4)	5·1 (4·2)	6·3 (4·1)	2·3 (3·6)	3·3 (3·2)	5·2 (4·1)	3·0 (3·7)	2·4 (3·5)	2·9 (3·5)
RAND									
Physical functioning	89·5 (13·8)	92·0 (11·2)	94·1 (9·7)	92·6 (10·9)	94·3 (7·3)	96·2 (5·2)	90·4 (15·6)	95·4 (8·5)	96·5 (5·2)
Social functioning	69·3 (21·3)	76·4 (22·2)	82·1 (21·4)	94·8 (11·8)	90·8 (13·1)	87·5 (14·8)	85·8 (22·3)	91·7 (11·5)	92·2 (12·1)
Physical problems	79·0 (29·5)	84·0 (30·5)	86·6 (22·0)	87·1 (28·0)	86·7 (28·4)	89·3 (26·9)	79·5 (35·0)	90·4 (22·4)	88·5 (26·0)
Emotional problems	51·0 (36·4)	70·5 (33·1)	70·2 (35·5)	93·1 (16·4)	88·9 (22·0)	79·4 (28·8)	83·3 (35·3)	87·2 (23·2)	90·3 (18·3)
Vitality	44·2 (21·0)	56·9 (24·9)	54·3 (21·4)	71·2 (14·3)	69·7 (19·4)	57·3 (17·9)	68·9 (19·4)	70·7 (18·6)	67·5 (18·4)
General mental health	63·0 (17·3)	68·7 (17·2)	67·6 (17·7)	80·1 (13·7)	78·4 (12·3)	72·2 (12·9)	74·9 (19·3)	78·6 (14·2)	77·8 (15·2)
General health perceptions	71·3 (21·6)	69·0 (20·3)	73·6 (16·4)	78·8 (20·2)	74·8 (20·5)	75·7 (12·3)	74·5 (21·5)	79·4 (17·7)	78·5 (12·6)
Pain	75·4 (23·3)	75·5 (25·6)	75·6 (18·9)	80·9 (21·4)	82·5 (19·9)	81·8 (14·0)	78·5 (17·9)	85·1 (18·3)	85·4 (19·0)

Abbreviations: SIGH-SAD-SR, Structured Interview Guide for the Hamilton Depression Rating Scale – Seasonal Affective Disorders Version Self-Rating Format; HDRS, Hamilton Depression Rating Scale; RAND, RAND 36-item Health Survey 1.0.

respondents from group A, 24 from group B and 19 from group C, which surpassed the required sample size in each group. There was no significant difference in the baseline values between the subjects with incomplete and complete data.

There were no differences in the outcome measures between the subgroups of subjects without ($N = 57$) or with ($N = 37$) subsyndromal SAD. The intensity of retrospective season-dependent symptoms, analysed both as a continuous and a categorized variable, was not associated with the outcome measures. The findings remained essentially similar after excluding those subjects who experienced the score of 10 or over on the GSS as a problem at least to a moderate degree and scored 19 or over on the HDRS of the SIGH-SAD-SR ($N = 5$).

Physical exercise combined with bright-light exposure (group A) or alone (group B) significantly improved the scores of atypical depressive symptoms ($F(1,76) = 8{\cdot}4$, $P = 0{\cdot}005$, observed power of 0·82, adjusted R^2 of 0·19) and typical depressive symptoms ($F(1,76) = 14{\cdot}6$, $P < 0{\cdot}001$, observed power of 0·97, adjusted R^2 of 0·36) rated at week 8 compared to the active placebo (group C). Several fitness test results increased significantly among the subjects allocated to groups A and B, indicating that the supervised physical exercise had been strenuous enough to result in improved fitness, but the extent of change did not differ significantly between the two groups.

Addition of bright-light exposure to physical exercise resulted in significantly reduced scores of atypical depressive symptoms ($F(1,76) = 15{\cdot}4$, $P < 0{\cdot}001$, observed power of 0·97, adjusted R^2 of 0·26) and typical depressive symptoms ($F(1,76) = 12{\cdot}0$, $P = 0{\cdot}001$, observed power of 0·93, adjusted R^2 of 0·34) rated at week 8.

The scores of atypical ($F(2,75) = 8{\cdot}7$, $P < 0{\cdot}001$, observed power of 0·96, adjusted R^2 of 0·26) and typical ($F(2,75) = 9{\cdot}8$, $P < 0{\cdot}001$, observed power of 0·98, adjusted R^2 of 0·38) symptoms of depression rated at week 8 were significantly influenced by group. The scores of atypical or typical depressive symptoms rated at follow-up were not significantly affected by group. Table 1 presents the ratings of mood and health-related quality of life by group. The changes in these ratings are shown in Table 2.

At week 8, the improvement in atypical

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Table 2. *Mean differences (95% CI) in the ratings by intervention group*

	Difference between baseline and week 8			Difference between week 8 and follow-up		
	Group A $N = 28$	Group B $N = 30$	Group C $N = 21$	Group A $N = 23$	Group B $N = 23$	Group C $N = 19$
SIGH-SAD-SR						
HDRS symptoms	−7·9 (−10·2 to −5·7)	−5·0 (−6·9 to −3·0)	−1·2 (−3·1 to 0·7)	2·7 (−0·2 to 5·6)	0·4 (−1·6 to 2·4)	−2·4 (−5·2 to 0·5)
Atypical symptoms	−7·0 (−9·2 to −4·8)	−1·7 (−2·9 to −0·5)	−1·5 (−3·4 to 0·4)	1·2 (−0·4 to 2·8)	−0·9 (−2·4 to 0·6)	−2·1 (−4·0 to −0·1)
RAND						
Physical functioning	3·4 (0·8 to 6·0)	2·6 (−0·6 to 5·9)	2·1 (−0·5 to 4·8)	−1·5 (−4·4 to 1·4)	0·9 (−1·5 to 3·3)	−0·5 (−3·2 to 2·1)
Social functioning	25·9 (17·1 to 34·7)	14·6 (7·0 to 22·1)	5·4 (−2·4 to 13·1)	−9·7 (−18·7 to −0·6)	−1·1 (−6·5 to 4·3)	4·6 (−1·1 to 10·4)
Physical problems	7·4 (−6·1 to 20·9)	1·9 (−12·0 to 15·9)	4·8 (−12·7 to 22·3)	−8·0 (−26·5 to 10·6)	1·1 (−13·6 to 15·8)	−2·6 (−23·6 to 18·4)
Emotional problems	42·3 (28·1 to 56·4)	18·9 (6·4 to 31·4)	11·1 (−1·9 to 24·1)	−9·1 (−26·3 to 8·1)	−1·5 (−10·0 to 7·0)	10·5 (−7·3 to 28·3)
Vitality	26·7 (18·5 to 34·9)	13·7 (9·2 to 18·1)	1·3 (−6·2 to 8·8)	−4·3 (−10·8 to 2·1)	−1·7 (−8·5 to 5·0)	7·8 (−0·7 to 16·2)
General mental health	16·1 (9·8 to 22·5)	10·0 (5·7 to 14·2)	3·8 (−0·5 to 8·1)	−6·0 (−12·6 to 0·6)	−0·8 (−6·1 to 4·4)	3·6 (−1·3 to 8·4)
General health perceptions	5·7 (0·5 to 11·0)	6·7 (1·9 to 11·4)	1·2 (−5·4 to 7·8)	−4·5 (−11·7 to 2·8)	1·5 (−6·6 to 9·7)	1·1 (−4·0 to 6·0)
Pain	6·7 (−0·3 to 13·7)	7·4 (−1·1 to 15·9)	5·8 (−2·2 to 13·8)	−2·0 (−13·6 to 9·5)	3·6 (−3·8 to 11·0)	−0·3 (−10·2 to 9·7)

Abbreviations as in Table 1.

depressive symptoms ($\chi^2 = 15{\cdot}0$, df = 1, $P < 0{\cdot}001$), vitality ($t = 2{\cdot}9$, df = 42·0, $P = 0{\cdot}007$) and role limitations caused by emotional problems ($\chi^2 = 5{\cdot}1$, df = 1, $P = 0{\cdot}02$) was significantly greater in group A then group B. In addition, the improvement in both atypical ($t = -3{\cdot}9$, df = 47·0, $P < 0{\cdot}001$) and typical ($t = -4{\cdot}7$, df = 46·9, $P < 0{\cdot}001$) symptoms of depression, vitality ($t = 4{\cdot}7$, df = 44·7, $P < 0{\cdot}001$), role limitations caused by emotional problems ($\chi^2 = 8{\cdot}7$, df = 1, $P = 0{\cdot}003$), general mental health ($t = 3{\cdot}3$, df = 43·5, $P = 0{\cdot}002$) and social functioning ($\chi^2 = 9{\cdot}2$, df = 1, $P = 0{\cdot}002$) was significantly greater in group A than group C. The improvement in typical depressive symptoms ($t = -2{\cdot}9$, df = 48·0, $P = 0{\cdot}006$) and vitality ($t = 3{\cdot}0$, df = 31·3, $P = 0{\cdot}006$) was significantly greater in group B than group C.

At follow-up, the deterioration in atypical depressive symptoms ($\chi^2 = 4{\cdot}7$, df = 1, $P = 0{\cdot}03$) was significantly greater in group A then group B. In addition, the deterioration in both atypical ($\chi^2 = 7{\cdot}3$, df = 1, $P = 0{\cdot}007$) and typical ($\chi^2 = 5{\cdot}3$, df = 1, $P = 0{\cdot}02$) symptoms of depression, vitality ($t = -2{\cdot}4$, df = 33·7, $P = 0{\cdot}02$), general mental health ($t = -2{\cdot}4$, df = 36·5, $P = 0{\cdot}02$) and social function ($\chi^2 = 5{\cdot}7$, df = 1, $P = 0{\cdot}017$) was significantly greater in group A than group C.

DISCUSSION

Our key finding was that physical exercise combined with exposure to bright light was significantly more effective at improving mood than fitness training in ordinary room light, or relaxation alone. Compared with both of the latter interventions it resulted in significantly greater improvement on the scale measuring the intensity of atypical depressive symptoms. Physical exercise alone produced only modest benefit compared to relaxation.

Relatively little is known about healthy individuals in terms of seasonal influences and the effects of physical exercise or exposure to bright light on psychological well-being. Our findings now support the assumption that exposure to bright light, at least in combination with supervised physical exercise, may improve mood among healthy adults, independently of their history of season-dependent symptoms. Our results also show that fitness training in

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bright light improved the health-related quality of life. The improvement was most pronounced in the RAND scales, which measure vitality, general mental health and social functioning. The assessment of vitality corresponds closely with that of mood, and the increased vitality is suggested above all to reflect the improvement in mood. It is noteworthy that this finding remained unchanged after excluding from analysis those subjects who had no clinical depression but a relatively high score of depressive symptoms.

The strengths of our study are the relatively large sample size and long intervention period, including the follow-up assessment. On the other hand, a shortcoming is that the intensity of fitness training was not measured or maintained at a set level. We considered that an adequate frequency of training would be more important for the outcome than a strictly monitored fixed intensity, since improvement in mood had been observed in depressed subjects after both aerobic and non-aerobic exercise (Martinsen *et al.* 1989). It is participation in physical exercise rather than cardiovascular performance that has been associated with mood improvements (Thirlaway & Benton, 1992).

Another shortcoming is that the completeness differed in each group. Our results cannot necessarily be generalized to the whole population, because those who decided to participate were asked to take some interest in gym training, so some selection must have occurred. A third shortcoming is the preponderance of women in our sample. It is unlikely that the gender distribution compromised our findings, since menstrual-cycle stage and menopausal state do not influence the reliability of mood assessment or symptom reporting (Schwartz *et al.* 1997; Slaven & Lee, 1997).

In conclusion, we suggest that supervised physical exercise plus exposure to bright light may be an effective short-term intervention to improve mood and particular aspects of the health-related quality of life in healthy adults during winter. It seems less suitable as a preventive measure though, since the beneficial effect had vanished by the time of the follow-up assessment 4 months after stopping the supervised training. Further research is needed to discover whether the combination of supervised physical exercise and bright light is a useful option for improving mood and vitality at large. Future studies should also focus on separating the efficacy of the two interventions.

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