Randomized Trial of the Efficacy of Bright-Light Exposure and Aerobic Exercise on Depressive Symptoms and Serum Lipids

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Background: Season-related subsyndromal depressive symptoms during winter are common among populations at high latitudes. Both physical exercise and exposure to bright light can relieve the fatigue and downturn of mood associated with the shortening length of day. Serum cholesterol level may be related to changes in mood, but the evidence is contradictory. Our objective was to compare the effect of aerobic exercise with or without bright-light exposure on health-related quality of life, mood, and serum lipids in a sample of relatively healthy adult subjects.

Method: A randomized controlled trial was conducted with subjects allocated to group aerobics training in a gym with bright light (2500–4000 lux) (N = 40) or normal illumination (N = 42) or to relaxation/stretching sessions in bright light as a control group (N = 42) twice a week for a period of 8 weeks. Changes in mood were recorded using questionnaires at the beginning of the study, at weeks 4 and 8, and at follow-up 4 months after the study. A blood sample was drawn before and after the 8-week intervention to measure the concentrations of serum lipids.

Results: Ninety-eight subjects completed the 8-week study. Both exercise and bright light effectively relieved depressive symptoms. Bright light reduced atypical depressive symptoms more than exercise (p = .03), based on the atypical symptoms subscore of the Structured Interview Guide for the Hamilton Depression Rating Scale-Seasonal Affective Disorders Version Self-Rating Format. There were no significant differences between the study groups in the changes in serum lipid levels.

Conclusion: Bright light administered twice a week, alone or combined with physical exercise, seems to be a useful intervention for relieving seasonal mood slumps.

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Seasonal mood change, especially "winter blues," is not an uncommon phenomenon among people living near or above the arctic circle, where the length of day is drastically short during the winter months. The prevalence of seasonal affective disorder (SAD) in northern European populations is estimated to be 0.5% to 1.5%, but up to 10% to 20% of such populations report episodes of milder but recurrent symptoms during the wintertime (subsyndromal SAD).[1,2] Bright light is considered the treatment of choice for SAD,[3] and it may also have beneficial effects on mood in healthy subjects.[4] Winter depression is characterized by atypical depressive symptoms, which include hypersomnia, afternoon or evening slump, weight gain, and increased appetite, especially carbohydrate craving.[5] In our earlier study,[6] physical exercise had a positive effect on mood and health-related quality of life in relatively healthy subjects, and physical exercise combined with bright light seemed to provide added efficacy. Low total serum cholesterol level has been associated with violent death, anxiety, depression, and aggressive behavior,[7,8] but the evidence is controversial, and lowering serum cholesterol by medication or diet probably does not have negative effects on mood.[9] Our hypothesis was that in a sample of relatively healthy adults, the combination of aerobic group exercise and exposure to bright light would improve health-related quality of life and mood and lower serum lipid levels without harmful side effects and more

effectively than similar exercise in normal room illumination or relaxation/stretching group sessions with bright-light exposure.

METHOD

We enrolled subjects from among employees at several occupational health care centers in Helsinki, Finland (60°N). The target population was approximately 15,000 persons. All employees received information about the study, and volunteers were invited to contact the medical staff of the center at which they worked. The eligibility of subjects was checked by the chief physician of each center, who was blind to the randomization procedure. Exclusion criteria were a severe general medical condition, progressive eye disease, and participation in our study from the previous year.

Intervention

The randomization procedure was devised by the medical director at the gym (VITA Health Services, Helsinki, Finland). The physiotherapists who supervised the groups were not involved in the randomization and were blinded to study code before treatment allocation. Block randomization was done by the staff of each occupational health center according to the lists we provided. One hundred twenty-four subjects were randomly assigned to 3 groups: aerobics training in bright (2500–4000 lux) light (Light Plus Aerobics), aerobics training in the normal (400–600 lux) lighting of the gym (Aerobics), or relaxation and stretching in bright light (Light Plus Stretching). All training took place in the same gym, to the ceiling of which were attached 30 extra light fixtures with cool-white (6000 K) fluorescent lamps (F58W/186, Sylvania, Germany); these were turned on for Light Plus Aerobics and Light Plus Stretching sessions. The intensity of light for these subjects was regularly checked to be 2500 to 4000 lux at eye level, depending on the position of the body. The subjects were instructed not to stare directly at the lamps. For Aerobics subjects, the gym was lit normally with regular lamps (F36W/186) emitting cool-white (6000 K) fluorescent light. All exercise sessions lasted 45 minutes, twice a week, for 8 weeks. There were 15 training sessions in all, 1 day for each group being a public holiday. The group sessions started at 7:30 a.m. or 8:30 a.m. Monday through Friday and at 10:00 a.m. or 11:00 a.m. on Saturdays. The trial was conducted between November 25, 1997, and January 25, 1998. The length of the day on these dates was 6 h 48 min and 7 h 23 min, respectively.

The aerobics training and relaxation/stretching sessions were led by 3 physiotherapists, who switched regularly during the trial so that each supervised one third of each study group's training sessions. In the groups receiving aerobics training, the intensity of training was checked during the first few weeks with a pulsemeter, and the heart rate of the subjects ranged between 120 and 150 beats per minute. The relaxation/stretching training was planned to be nonaerobic, to avoid raising the heartbeat. To maintain treatment consistency, both types of session were structured and included the same items at each visit.

Assessment

At the start of the study and at weeks 4 and 8, all subjects were weighed to assess body mass index (BMI). Immediately before and after the study, subjects in the Light Plus Aerobics and Aerobics groups participated in a 2-km walking test that predicts the maximal oxygen uptake using a model with age, sex, walking time, BMI, and heart rate at the end of the test as variables.[10] Before and after the intervention, a blood sample was collected from all participants, from which the concentrations of total serum cholesterol, high-density lipoproteins, and triglycerides were determined. All blood samples were analyzed in the same laboratory (VITA Health Services, Helsinki, Finland), using the enzymatic colorimetric method.[11]

At baseline, all subjects filled in the Seasonal Pattern Assessment Questionnaire (SPAQ),[12] the Structured Interview Guide for the Hamilton Depression Rating Scale-Seasonal Affective Disorders Version Self-Rating Format (SIGH-SAD-SR),[13] the RAND 36-Item Health Survey 1.0 (RAND),[14] the Basic Nordic Sleep Questionnaire (BNSQ),[15] and a modified 26-item FINRISK questionnaire (FINRISK).[16] The SPAQ measures seasonal changes in mood and behavior and includes a 6-item scale yielding the Global Seasonality Score (GSS). The SPAQ criteria for subsyndromal SAD used in this study were those described by Bartko and Kasper.[17] These criteria require that subjects have a GSS of 10 or more and experience seasonal change as no more than a mild problem (on a scale of 1 to 5 ranging from mild to disabling) or a GSS of 8 or 9 and experience seasonal change as at least a mild problem. The SIGH-SAD-SR includes the 21-item Hamilton Rating Scale for Depression (HAM-D) and an 8-item addendum for scoring atypical symptoms of depression with separate questions for social avoidance, weight gain, increased appetite and eating, carbohydrate craving, prolonged sleep, general fatigue, and afternoon slump. The RAND measures 8 dimensions of functioning that reflect the perceived health-related quality of life: physical functioning, social functioning, role limitations caused by physical problems and emotional problems, vitality, general mental health, bodily pain, and general health perceptions. The dimensions used in the RAND are identical to those in the Medical Outcomes Study 36-Item Short Form Health Survey (SF-36),[18] but the scoring algorithm used is somewhat different.[14] The NBSQ has 21 questions measuring the quality and length of sleep and problems related to sleep. The abbreviated FINRISK consists of 26 questions concerning smoking, alcohol consumption, dietary fat intake, and habitual exercise. At weeks 4 and 8 and at follow-up 4

months after the study, the subjects again completed the SIGH-SAD-SR and RAND.

Statistics

The calculation of sample size was based on the expected reduction in atypical depressive symptoms. The estimate of the standard deviation (5 points) for the atypical symptom score was based on the results of a previous study.[19] We accepted a 5% risk of committing type I and II errors and a maximum difference of 6 points between the atypical score means of the Light Plus Aerobics and Aerobics groups. The minimum number of subjects required in each group was 18. Our main outcome measures were the scores on the SIGH-SAD-SR and the RAND, as well as the changes in these scores during the intervention and at the follow-up. To calculate the effect of bright light versus normal light and aerobic exercise versus stretching/relaxation, a linear mixed-effect model for repeated-measures data was used, as described by Laird and Ware[20] and Lindstrom and Bates.[21] The response variable was the difference between baseline and follow-up for each individual at each timepoint (at 4 and 8 weeks and 4 months after the study). The baseline scores for the relevant outcome variable, sex, age, light exposure, and physical exercise were entered as covariates. The difference between the effects of exercise and light was tested with the Wald test. The data were screened and analyzed with the S-Plus 2000 Professional Edition for Windows, Release 1 (Mathsoft Inc., Cambridge, Mass.).

Ethics

The study was approved by the ethics committee of the National Public Health Institution, Helsinki, Finland. All subjects gave their written informed consent prior to participation.

RESULTS

The 124 subjects were randomly assigned to the 3 groups as follows: 40 in the Light Plus Aerobics group, 42 in the Aerobics group, and 42 in the Light Plus Stretching group. Four subjects in the Aerobics group did not start the trial. We received at least 1 questionnaire from 120 participants. Of these, 22 subjects (8, 9, and 5 in the Light Plus Aerobics, Aerobics, and Light Plus Stretching groups, respectively) were excluded from the analysis because of failure to return all of the questionnaires during the study period, so complete data were received on 98 subjects. Table 1 shows the demographic data of the study subjects, and Table 2 shows their baseline scores. Of those who completed the trial, 30 subjects (9, 10, and 11 in the Light Plus Aerobics, Aerobics, and Light Plus Stretching groups, respectively) did not return the follow-up questionnaire 4 months after the trial, so we had follow-up data for 68 subjects. These subjects did not differ on any of the baseline or outcome measures from the 30 subjects who failed to return the follow-up form.

Table 1. Baseline Characteristics of the Study Subjects[a]

Value	All	Light Plus Aerobics	Aerobics	Light Plus Stretching
Male, N (%)	11 (11)	3 (9)	2 (7)	6 (16)
Female, N (%)	87 (89)	29 (91)	27 (93)	31 (84)
Age				
Mean (SD)	43.4 (9.6)	41.8 (9.2)	45.5 (10.2)	43.2 (9.4)
Range	26–63	27–55	27–63	26–59
BMI				
Mean (SD)	24.2 (3.7)	23.6 (3.1)	24.1 (3.6)	24.7 (4.3)
Range	16–39	18–33	19–33	16–39
GSS				
Mean (SD)	10.5 (4.9)	10.1 (5.2)	10.5 (4.6)	10.9 (5.1)
Range	0–22	0–21	4–22	0–22
With subsyndromal SAD, N (%)	39 (40)	8 (25)	13 (45)	18 (49)
Without subsyndromal SAD, N (%)	59 (60)	24 (75)	16 (55)	19 (51)

[a]Abbreviations: BMI = body mass index, GSS = Global Seasonality Score, SAD = seasonal affective disorder.

Table 2. Mean Baseline Values of the Outcome Measures[a]

	All (N = 98)		Light Plus Aerobics (N = 32)		Aerobics (N = 29)		Light Plus Stretching (N = 37)	
Scale	Mean	SD	Mean	SD	Mean	SD	Mean	SD
SIGH-SAD-SR								
HAM-D	10.5	6.4	10.8	7.0	9.0	5.2	11.4	6.6
Atypical symptoms	5.9	4.3	6.2	4.9	5.1	3.7	6.3	4.2
RAND								
Physical functioning	92.2	11.2	95.6	8.5	90.7	7.8	90.4	14.6
Social functioning	77.4	23.3	78.9	24.3	84.1	12.5	71.0	27.5
Physical problems	85.6	26.2	88.3	23.8	88.8	21.7	81.8	31.0
Emotional problems	67.4	36.8	62.5	39.5	77.0	31.0	64.0	38.0
Vitality	52.2	22.8	52.2	27.2	58.3	18.3	47.4	21.1
General mental health	66.7	18.0	67.9	21.7	71.0	12.6	62.3	17.6
General health perceptions	68.1	19.3	70.2	19.9	73.8	14.4	61.9	20.7
Pain	83.6	17.4	84.9	16.2	81.1	17.5	84.4	18.7

[a]Abbreviations: HAM-D = Hamilton Rating Scale for Depression, RAND = RAND 36-Item Health Survey 1.0, SIGH-SAD-SR = Structured Interview Guide for the Hamilton Depression Rating Scale-Seasonal Affective Disorders Version Self-Rating Format.

Trial Effects on Outcome Measures

In the repeated-measures analysis (bright vs. normal light and exercise vs. stretching/relaxation), the effect of bright light was significant on both the atypical symptoms score of the SIGH-SAD-SR ($p = .02$) and the HAM-D score ($p = .05$), whereas exercise reduced only the HAM-D score ($p = .02$) during the trial (Table 3). Bright light was significantly more effective than exercise in reducing the atypical symptom score ($\chi^2 = 4.5$, $p = .03$), but not the HAM-D

Table 3. Estimates of the Effect of Light and Exercise (95% CI) on the Main Outcome Measures[a]

Scale	Light	Exercise
SIGH-SAD-SR		
HAM-D	–2.5 (–4.4 to 0.0)*	–2.5 (–4.6 to –0.4)***
Atypical symptoms	–2.0 (–3.6 to –0.3)***	–0.4 (–2.0 to 1.1)
RAND		
Physical functioning	3.0 (–2.2 to 8.2)	4.0 (–0.8 to 8.8)
Social functioning	0.5 (–10.2 to 11.1)	7.1 (–3.5 to 17.7)
Physical problems	4.5 (–8.0 to 16.9)	7.5 (–4.3 to 19.2)
Emotional problems	9.9 (–8.1 to 27.9)	3.1 (–14.1 to 20.2)
Vitality	12.7 (0.3 to 25.1)**	5.1 (–6.8 to 17.1)
General mental health	4.9 (–6.2 to 15.9)	1.8 (–9.2 to 12.8)
General health perceptions	13.9 (4.0 to 23.7)****	7.8 (–1.5 to 17.0)
Pain	6.8 (–3.2 to 16.7)	9.0 (–0.2 to 18.3)

[a]Abbreviations: CI = confidence interval, HAM-D = Hamilton Rating Scale for Depression, RAND = RAND 36-Item Health Survey 1.0, SIGH-SAD-SR = Structured Interview Guide for the Hamilton Depression Rating Scale-Seasonal Affective Disorders Version Self-Rating Format.
*p = .05.
**p = .045.
***p = .02.
****p = .008.

score ($\chi^2 = 0.08$, p = .8). Bright light improved scores on the scales of general health perceptions (p = .008) and vitality (p = .045). However, the differences between the intervention effects were not significant on any of the RAND scales. The symptom scores did not change markedly from week 8 to follow-up.

In both exercise groups (Light Plus Aerobics and Aerobics), the fitness test results showed significant and similar improvement in cardiovascular performance during the study, demonstrating that the training had been both adequate and equal in the groups. BMI did not change significantly in any of the study groups during the trial. Statistical analysis showed no significant differences in changes in total serum cholesterol, high-density lipoprotein, or triglyceride levels between the groups during the intervention. There was a minor increase in total serum cholesterol from baseline in the Aerobics group (t = 2.1, df = 30, p = .04).

Subsyndromal SAD

There were no marked differences in the results of the outcome measures of those who fulfilled the SPAQ criteria for subsyndromal SAD (N = 39) compared with those who did not (N = 59). The results remained similar after excluding those who fulfilled the criteria for subsyndromal SAD and simultaneously scored 19 or more on the HAM-D (N = 9).

Compliance

One subject from the Light Plus Stretching group withdrew after the first session because of back pain. No other adverse effects attributed to the exercise, relaxation/stretching, or bright light were reported. The subjects signed in at each group session so that their adherence to the training could be followed. Subjects were asked to notify the physiotherapist leading their group if they were unable to participate in a session. Work obligation or illness (e.g., common cold) were the main reasons participants gave for their absence. The mean ± SD number of training sessions participated in was 11.0 ± 3.7 overall and 10.7 ± 4.2, 10.5 ± 3.9, and 11.8 ± 2.9 in the Light Plus Aerobics, Aerobics, and Light Plus Stretching groups, respectively.

DISCUSSION

Our major finding was that both aerobic exercise and administration of bright light have a positive effect on mood and health-related quality of life. This favorable effect was seen in those subjects who reported recurring seasonal symptoms, but also in the subjects whose symptoms did not fulfill the criteria used for subsyndromal SAD. In addition, subjects in the groups with exposure to bright light showed significant improvement in both typical and atypical depressive symptoms, whereas exercise alone failed to reduce the atypical symptom scores. The protocol augmented our previous trial[6] by enabling us to study the efficacy of bright-light exposure combined with supervised relaxation.

A shortcoming of the present study was that we did not have a control group of subjects participating in stretching/relaxation in normal light. This limitation in study design renders it impossible to make a definitive statement about the effects of bright light or exercise when compared with placebo. Also, because of practical reasons, the illumination of the gym (400–600 lux) could not be attenuated closer to ordinary room lighting (< 250 lux), which might have provided a better control for comparison of the aerobics groups.

Exercise behavior influences health-related quality of life, especially affecting mental health scale scores and vitality level.[22] In the present study, both exercise and bright light improved the RAND scale scores, but the improvements were small and failed to reach statistical significance, possibly due to a ceiling effect. The baseline RAND scores were quite high in all groups, which limited the extent of their improvement.

At follow-up (May–June 1998), none of the groups had worsened on any of the scales of mood or health-related quality of life. In patients with SAD, a natural remission occurs in summer, and a greater improvement in mood has been observed in summer than with light treatment during winter in SAD patients.[23] Subjects suffering from subsyndromal SAD may be expected to follow a similar course of symptoms. However, despite 2 letters of encouragement sent to nonresponders, only 69% of those who completed the trial returned the follow-up questionnaires, which limits the interpretation of these results.

The results from the present study and our earlier study suggest that combining supervised physical exercise with bright light administration has beneficial effects on mood and health-related quality of life when compared with physical exercise alone. The effect is most pronounced on atypical depressive symptoms. However, the mechanism of this possible additive effect remains obscure. Both bright light and exercise influence circadian rhythms. Bright light in the morning has been shown to induce a phase advance of circadian rhythms,[24] and morning exposure also seems to be superior in the treatment of SAD.[25] To date, there is evidence that nighttime or early morning exercise results in a phase delay of melatonin onset the next evening.[26] Physical performance is generally better in the afternoon and evening compared with the morning. However, it seems that the positive effect of exercise on mood states is independent of the time of day,[27,28] implying that factors other than circadian phase shifts may mediate the mood-lifting effect of exercise.

The association between serum cholesterol levels and mental health is a widely studied but controversial issue. Lowering of serum cholesterol levels, either by medication[29] or by diet,[30] does not seem to have harmful effects on mood. Research supports the importance of physical activity in lowering serum lipid levels[31] when the follow-up periods are longer, but there is preliminary evidence that even a single intensive exercise session affects at least high-density lipoproteins.[32] In this study, there was a reduction in carbohydrate craving in all groups during the trial, but this was not correspondingly reflected in the serum cholesterol levels. We found no correlations between cholesterol levels, or changes in them, and any of the used measures of mood. Neither did the changes in BMI correlate with serum lipid changes.

Another shortcoming of our study was that the subjects' expectations were not measured before the trial, which might have led to a bias in favor of the bright light groups. The preintervention expectations seem to correlate positively with the decrease in typical depressive symptoms, but not with the reduction of atypical depressive symptoms.[5]

The present study seems to support the earlier results concerning the effects of light and exercise. We suggest that a short-term, 4- to 8-week intervention of bright light exposure, combined with relaxation or, more preferably, with supervised exercise, during winter might be sufficient to alleviate mild, season-related depressive symptoms. However, the beneficial effect of this kind of intervention on subjects without season-bound symptoms cannot be generalized yet, but needs replication and further verification in the future.

Disclosure of off-label usage: The authors have determined that, to the best of their knowledge, no investigational information about pharmaceutical agents has been presented in this article that is outside U.S. Food and Drug Administration–approved labeling.

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