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Sun Exposure and Behavioral Activation for Hypovitaminosis D and Depression: A Controlled Pilot Study

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Abstract
Several independent meta-analytic reviews suggest a relationship between vitamin D (VTD) deficiency and depressive symptoms. Theoretically, behavioural withdrawal (staying home, discontinuing outdoor activities etc.) is likely to exacerbate VTD deficiency. This pilot study assessed the efficacy of a modified form of behavioral therapy designed to simultaneously target VTD deficiency and depressive symptoms. College women ($N=114$), all citizens of the United Arab Emirates, were screened for depressive symptoms and VTD deficiency. Those participants who were severely VTD deficient and experiencing clinically significant depressive symptoms, were randomly allocated to either a 12-week program of behavioral activation, emphasizing safe-sun exposure ($N=10$), or a waiting list control group ($N=10$). At time 2 the sun exposure and behavioral activation (SEBA) group showed a significant increases in 25-hydroxyvitamin D and were, on average, no longer VTD deficient, whereas the control group deteriorated in terms of VTD. Similarly positive results were observed for depressive symptoms. Sun exposure and behavioral activation (SEBA) may be an effective approach to improving VTD status and alleviating depressive symptoms.

Keywords Depression · Vitamin D · Behavioural activation · Arab female

Introduction

Several chronic physical health morbidities (e.g. type 1 diabetes, colon cancer, cardio vascular diseases) have been associated with 25-hydroxyvitamin D (VTD) deficiency (Barnes et al. 2006; Holick 2008). Increasingly attention is also being directed towards vitamin D's potential role in mental health problems, most notably mood disorders (Berk 2009). When depressed patients are compared with healthy controls, studies tend to find higher rates of VTD deficiency among the patient groups (Schneider et al. 2000). Like major depressive disorder, severe VTD deficiency (hypovitaminosis D) also appears to be more common among females, and both conditions are commonly co-morbid. One integrative review of six studies, reported a positive association between VTD deficiency and the incidence of mood disorders amongst women (Murphy and Wagner 2008). Similarly, amongst those over the age of 65—the capacity to synthesize VTD is diminished in the elderly—the prevalence of VTD deficiency and its link with mood disorders appears to be particularly pronounced (Stumpf and Thomas 1989). In a study of VTD, depression and cognitive performance in those over the age of 65, 58% of the participants were VTD deficient [VTD concentrations of less than 20 nanomoles per litre (< 20 nmol/L)]. Furthermore, there was a robust association between low VTD levels and the presence of mood disorders. Low VTD levels were also associated with poorer cognitive performance (Wilkins et al. 2006). A recent systematic review and meta-analysis of observational studies and randomised controlled trials compared data across 31,424 participants, concluding that VTD deficiency was associated with depression (Anglin et al. 2013).

In seasonal affective disorder the condition's temporal patterning has given rise to the idea that VTD deficiency, due to the reduced wintertime photoperiod, may play an important aetiological role (Berk et al. 2007). However, in nations like the United Arab Emirates (UAE) with a fairly consistent, year-round, photoperiod, it may actually be seasonal fluctuations in temperature that contribute to variations in VTD status and depressive symptoms. This idea has been termed the "sun avoidance hypothesis", and at least one

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UAE study reports significant summer-time spikes for both VTD deficiency and depressive symptomatology. (Thomas et al. 2011). Other studies in the Arabian Gulf region have similarly identified high rates of VTD deficiency in spite of the perennial sunshine (Dawodu et al. 1998; Saadi et al. 2006; Sedrani et al. 1983). This situation appears to be especially problematic among women (Molla et al. 2005; Siddiqui and Kamfar 2007). The preponderance of VTD deficiency in Arabian Gulf women may, in part, be attributable to Islamic and cultural mores advocating modest dress. In the UAE for example this dress typically includes extensive body covering, extending in some cases to veiling the face and covering hands and feet (Saadi et al. 2006). Dawodu et al. (1998) suggest the widespread VTD deficiency in the region is explicable in terms of residents tending to avoid exposure to sunlight because of the excessive heat especially in the summer months. Other proposed contributory factors include the UAE's high levels of obesity, relatively dark skin pigmentation, and the presence of dust in the atmosphere, all of which are factors that may play a role in reducing the skin's ability to synthesize VTD (Barnes et al. 2006). Several previous studies also confirm the correlation between VTD deficiency and depressive symptoms amongst citizens of the UAE (Al Anouti et al. 2011, 2013; Thomas et al. 2011).

The mass of evidence confirming the association between depression and VTD deficiency has given rise to speculations about possible temporal and causal factors underpinning this relationship. One psychological proposition suggests that depression is associated with behavioural withdrawal, which would typically reduce outdoor activity and therefore sun-exposure potentially leading to VTD deficiency. Alternatively, the somatic effects of VTD deficiency (fatigue, vague aches and pains) might contribute to a general lowering of mood; this could be viewed as the "psychologization" of somatic symptoms. Furthermore, these two propositions are not incompatible and could be viewed as working in a mutually exacerbatory manner (Thomas et al. 2010). Additionally, the identification of VTD receptors on neurons and glia in various regions of the brain (e.g. hippocampus, cingulate cortex), has led to speculations about VTD's relationships with neurotransmitters and pathophysiological processes previously implicated in theories of depression (Eyles et al. 2005; Fernandes de Abreu et al. 2009). There is presently a need for randomised controlled trials of VTD supplementation in the context of preventing and treating depression, which in turn may shed further light on possible causal dynamics (Anglin et al. 2013). However, in addition to or perhaps as an alternative to supplementation, it would also seem useful to explore the effect of psychological interventions on sun exposure behaviours as a strategy for reducing VTD deficiency.

As a psychological intervention, behavioural activation (BA) appears to offer a fairly common sense approach to the remediation of VTD deficiency. Derived from cognitive behaviour therapy (CBT), behavioural activation is an approach to treating depression that involves coaching clients to engage in avoided activities, especially activities deemed likely to result in a sense of achievement or pleasure (Martell et al. 2001). Unlike CBT, it does not focus directly on cognition. Several reviews of BA have found it to be just as effective as CBT in the treatment of adults with depression (Cuijpers et al. 2007; Ekers et al. 2007), while one meta-analytic review concluded that BA is an effective treatment for depression (Ekers et al. 2014). BA also has the additional advantage of being easier to learn and teach than the more multi-faceted cognitive approaches (Veale 2008). A core element of BA involves negotiating and scheduling activities with clients. Typically there is no attention paid to whether the scheduled activities take place indoors or outdoors, during the night or daytime. However, in the context of VTD deficiency there is likely to be advantages to scheduling daytime outdoor activities. Such a sun exposure in the context of behavioural activation (Sun Exposure and Behavioural Activation—SEBA) will potentially bring about an increase in VTD levels whilst simultaneously reducing depressive symptoms.

To date we can identify no studies that have explored the impact of psychological interventions simultaneously targeting VTD deficiency and depression. The present pilot study assessed the efficacy of SEBA in terms of increasing blood serum levels of 25-hydroxyvitamin D, and reducing depressive symptoms amongst VTD deficient individuals (< 20 nmol/L) who were also experiencing moderate to severe levels of depressive symptomatology. It was hypothesized that, over the study's 12-week duration, participants receiving SEBA would demonstrate greater improvements in VTD levels and depressive symptoms compared with waiting-list control participants.

Methods

Participants

Participants were a convenience sample of Emirati college women attending a university in Abu Dhabi. The university's degree programs are delivered in English, and all participants were bilingual in Arabic and English.

Measures

Vitamin D Status: Analysis of Serum 25(OH)D

Blood samples were taken from all participants to analyze serum 25(OH)D levels as an indicator of vitamin D status as per previous standard assessment protocols (Haq et al.

2009). Serum concentrations of 25(OH)D were measured using two different techniques, specifically DiaSorin's LIAISON analyzer and a technique known as high performance liquid chromatography (HPLC). The intra-assay coefficient of variation was 4% and the inter-assay coefficient of variation was 5.8%, well within the acceptable range. All analyses were undertaken within the laboratory facilities at Sheikh Khalifa Medical City in Abu Dhabi.

Depression

Depressive symptoms were assessed using the *Beck Depression Inventory II (BDI-II)* (Beck et al. 1996). This is a 21-item self-report inventory widely used for assessing the severity and intensity of depressive symptoms. Each item reflects either a cognitive or somatic-affective symptom of depression; items are rated from 0 to 3, with higher scores reflecting heightened symptom severity. Amongst North American college students, and hospital outpatients the BDI-II was found to have high internal consistency, the coefficient alphas were 0.93 and 0.92 respectively (Beck et al. 1996). Subsequent studies of the BDI-II's psychometric properties report favorably on the instrument's construct, convergent, and predictive validity, in various contexts, spanning several nations (Al-Musawi 2001; Osman et al. 2004; Sprinkle et al. 2002).

The BDI was translated into Arabic and back translated by PhD-level faculty within the university's Arabic language department, with additional input from an experienced bilingual consultant psychiatrist. Measures were presented to participants in dual language form, with items in English and Arabic alongside each other. Presentation in dual language form was deemed necessary within the present population due to a known variability in language dominance (Thomas et al. 2016). In the present study BDI-II demonstrated acceptable internal reliability $\alpha = 0.88$.

Procedure

Recruitment was undertaken in two phases. In phase one of the recruitment a university-wide email was sent, requesting participants for a study of VTD levels and depressive symptoms. The respondents ($N = 114$, Mean age 20.83, SD = 3.98) were assessed for both VTD levels and depressive symptoms (detailed below). A certified phlebotomist collected blood samples and a chartered psychologist scored depressive symptom checklists.

In phase 2 of the recruitment, participants with blood serum VTD concentrations of less than 20 nmol/L, and depression scores greater than 13, received a letter requesting their participation in a trial of sun exposure and behavioural activation (SEBA). In total 31 participants met the study criteria and 20 (64.5%) responded and agreed to participate in phase 2. The participants identified in phase 2 were from a variety of academic disciplines and at varying stages of their college degrees. In terms of age, there were no differences between the SEBA (M = 21, SD = 1.32) group and the waiting list control (M = 21, SD = 1.06).

All participants gave written informed consent. Zayed University Human Subjects ethics committee and the ethics committee at Sheikh Khalifa Medical City prospectively approved the study. Participants were taken to various outpatient clinics within Abu Dhabi city were a phlebotomist took blood for the VTD analysis. Prior to which, participants completed the BDI individually. Participants were fully debriefed and informed of their blood test results (VTD status) in writing within 1 week; follow-up consultations were offered in the case of deficiency. As previously mentioned, only participants with VTD levels below 20 nmol/L, and BDI scores greater than 13 were requested (in writing) to participate in the SEBA trail (phase 2). Using a random number generator, twenty eligible participants were randomly allocated the treatment group or waiting list (WL) conditions. Each participant in the treatment group attended 8 SEBA sessions over a 12-week period (the first four sessions were held weekly, then switching to bi-weekly for last four sessions). After the 12-week period, VTD levels and depression levels were assessed again using the same procedure as at time one. This study took place during fall term, October to January; this is when UAE temperatures are most tolerable.

Sun Enhanced Behavioural Activation

SEBA was delivered in a group setting by a UK qualified cognitive psychotherapist (first author of this paper). With the exception of the emphasis on safe sun-exposure, the SEBA group followed the standard behavioural activation format as detailed in a widely used CBT training program (PRAXIS 2009). Participants are initially socialized into the collaborative and exploratory nature of CBT and introduced to a cognitive model of depression, emphasizing the inter-relationship between cognition, emotion and behaviour. Then the ideas of behavioural activation were introduced and activity scheduling commenced. Additionally however, The SEBA group also discussed the role of VTD and the idea that VTD deficiency may exacerbate or maintain low mood and low energy levels. During week one, participants were tasked with keeping an activity log to establish baseline activity and sun-exposure levels. Subsequent sessions involved negotiating increases in activity (activity scheduling) based on discussions about goals, avoided activities and pre-morbid functioning (things they used to do prior to feeling down). As in standard behavioural activation, there was an emphasis of scheduling activities that were viewed as either pleasurable or conferring a sense of mastery. In the

SEBA group there was an additional emphasis of scheduling and encouraging routine daytime outdoor activities. Examples from the present study included: taking breakfast in the garden, parking the car further from mall entrance, praying the afternoon prayer on the roof. Progress, barriers and further activity scheduling were discussed at each session.

Data Analysis Strategy

Data were normally distributed and it was deemed most appropriate to use a one-way between-groups analysis of covariance ANCOVA to explore the main effects of SEBA. This model allows for the comparison of the differences in post-test means after accounting for pre-test values.

Results

25-Hydroxyvitamin D

Mean vitamin D levels for the whole phase 1 sample were 23.66 (SD = 12.31). Based on conservative guidelines for assessing VTD deficiency (Grant 2009; Sabetta et al. 2005) the rate deficiency rate (< 20 nmol/L) in the present study was 53.5%.

An independent groups *t* test revealed that participants in the SEBA and WL control groups didn't differ in terms of their pre-test (time 1) VTD levels; these were 10.50 (SD = 5.57) and 10.92 (SD = 6.23) respectively. At post-test (time 2) the SEBA and WL groups mean VTD levels were 19.52 (SD = 11.67) and 9.02 (SD = 4.97) respectively.

A one-way between-groups analysis of covariance (ANCOVA) was conducted to compare the effectiveness of SEBA, to a WL control, in terms of increasing VTD levels. The independent variable was intervention type (SEBA or WL), and the dependent variable was post-test VTD levels. Participants' scores on the pre-test VTD levels were used as the covariate in the analysis.

Preliminary checks were conducted to ensure there was no violation of the assumptions of normality, linearity, homogeneity of variance etc. After adjusting for pre-test scores, VTD scores were significantly higher for participants in the SEBA group, F (1,10) = 11.52, p = .003, partial eta squared = 0.40.

Depressive Symptoms

Mean BDI scores for the whole sample (phase 1) were 14.90 (SD = 9.22), this is comparable to normative data reported by Beck, Steer and Brown (1996) amongst north American college women. Phase 1 BDI-II scores correlated negatively with VTD scores (r [112] = − 0.18), this association was significant for a 1-tailed test, p = .02. For those participants recruited into phase 2, mean depressive symptoms scores were 23.2 (SD = 10.50), which would be categorized as moderate levels of depressive symptoms according to the inventory's manual (Beck et al. 1996).

For the participants in the SEBA and WL control group the mean pre-test (time 1) BDI scores were 23.8 (SD = 10.68) and 23.3 (SD = 9.06) respectively. Analysing these differences with an independent groups *t* test revealed no significant group differences. Post-test BDI scores for the SEBA and WL control groups were 13.1 (SD = 6.26) and 22.8 (SD = 10.96) respectively.

A one-way between-groups analysis of covariance (ANCOVA) was conducted to compare the effectiveness of SEBA to WL control in terms of decreasing depressive symptom levels. The independent variable was intervention type (SEBA or WL), and the dependent variable was post-test depressive symptom levels. Participants' scores for pre-test depressive symptom levels were used as the covariate in the analysis.

Preliminary checks were conducted to ensure there was no violation of the assumptions of normality, linearity, homogeneity of variance etc. After adjusting for pre-test scores, depressive symptom scores were significantly lower for participants in the SEBA group, F (1,20) = 7.05, p = .01, partial eta squared = 0.29.

Discussion

A relatively high rate (53.5%) of VTD deficiency was found in the present study, which accords with previous studies undertaken in the region (Dawodu et al. 1998; Molla et al. 2005; Saadi et al. 2006; Sedrani et al. 1983; Siddiqui and Kamfar 2007). It is not yet possible to conclusively determine the exact nature of the relationship between depression and VTD deficiency. Depression very often leads to social withdrawal and inactivity; being behaviourally withdrawn is likely to contribute to reduced sun exposure and therefore lower levels of VTD. Similarly, VTD deficiency may promote depressive symptoms, either at a neurochemical level or as a result of an individual "psychologizing" aches and pain, that is, providing a psychological explanation for the insidious somatic complaints often associated with VTD deficiency. Furthermore the two issues, depressive symptoms and VTD deficiency, may actually be mutually exacerbatory (serve to make each other worse).

The present findings demonstrated that by focusing on depressive symptoms and VTD deficiency simultaneously, improvements were made in both areas. The present study found that our adapted version of behavioural activation (Sun Exposure and Behavioural Activation: SEBA) appeared to reduce depressive symptoms and VTD deficiency by statistically and clinically significant margins. The development

of a systematic behavioural intervention targeting VTD deficiency is particularly important as sustaining behavioural changes is arguably far more effective than indefinite VTD supplementation, which appears to be a very common practice (Al-Anouti and Thomas 2009).

The present study however was a preliminary pilot study and as such it has several important limitations. The study relied on university participants so it generalizability is limited. However, in the context of the UAE more than 50% of the citizens are under the age of 25 (Thomas 2014) so a focus on young people is warranted. Our focus on females also limits generalizability, again however, previous research in the region suggests that females are at particular risk of VTD and depression for socio-cultural reasons (Thomas et al. 2011). Further limitations include the small sample size (below statistical power), and even though the effects are fairly sizable, partial eta squared of 0.40 and 0.29 for VTD and depression reduction, these findings should be viewed as tentative. A final limitation was that physical activity logs and sun exposure duration where not operationalized in a quantifiable manner. Future studies should be larger and try to ensure physical activity and sun exposure duration are quantified for all participants.

Despite the limitations of this pilot study SEBA appears to be a promising intervention targeting depression comorbid with hypovitaminosis D. In addition to viewing SEBA as a therapeutic intervention it might also be worth considering it in a preventative public health context and explore its efficacy prospectively in terms of preventing these chronic health complaints that are both directly or indirectly associated with a large burden of disability (Moussavi et al. 2007).

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