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Sleep Deprivation during Night Shift Alters White Blood Cell Indices

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Abstract: *Cognitive impairment is a common important effect of night time sleep loss. However, in addition, compelling evidence links sleep loss to alterations in the metabolic, endocrine, immune and inflammatory systems with potential clinical relevance. The aim of the study was to determine the effect of sleep deprivation on white blood cell indices in night shift nurses. Twenty one (21) subjects during their night shifts were used for the study (10 males and 11 females). Blood samples (2ml) were collected from the subjects via venepuncture and analysed using standard methods to determine the total white blood cell count and differential white blood cell count. Samples were collected at the commencement of the night shift and after four days of night shift duty. Results were presented as mean ± S.D and data analysed with paired t-test with a level of significance of p<0.05. The result showed a significant decrease in mean white blood cell count (from 5.41± 1.42× 10^3cells/µl to 4.47 ± 0.97 × 10^3cells/µl at p< 0.001) and mean neutrophil differential count (58.43 ± 9.00% to 47.10 ± 11.30%) at p < .0.05. There wasa significant increase in differential lymphocyte count (from 33.38 ± 10.13% to 43.86 ± 7.37 % at p< 0.001). Sleep deprivation in night shift nurses was associated with a significant decrease in mean white blood cell count and mean differential neutrophil counts with an increase in the mean differential lymphocyte count.*

Keywords: *immune cells, nurses, sleep deprivation, sleep loss, shift work.*

I. Introduction

Sleep has for long been regarded as a simple suspension of activity, today it is appreciated as a complex and highly organized series of physiological and behavioural states (Foster and Wulff, 2005). Sleep is understood to possess recuperative properties and, conversely, sleep loss is associated with disease and a shortened life span (Everson et al., 2008).

The introduction of artificial lighting and the re-structuring of working hours have progressively detached us from 24-hour cycle of light and dark with consequent demotion of sleep in our priorities.

A working culture of shift work, to ensure a 24 –hour availability of most services including medical services in the hospital settings, demands staff to perform with equal efficiency throughout the 24 hours of a day. This often assumes precedence over the basic physiologic principles governing sleep and wakefulness (Owens, 2005). Attempts to sleep during the day time with a declining phase of melatonin and the rising phase of core body temperature, as in night-shift workers, usually results in a shorter and less well consolidated sleep episode (Dijket al., 1999). This disruption of the sleep–wake axis, results in a broad range of interconnected pathologies which include poor vigilance and memory, reduced mental and physical reaction times, reduced motivation, depression, insomnia, metabolic abnormalities, obesity, risk of cancer and immune impairment (Voderholzeret al., 2012; Foster and Wulff, 2005;Vgontzas and Chrousos, 2002; Davis et al., 2001).

Immune impairment secondary to sleep loss includes effects on circulating immune complexes, secondary antibody responses and antigen uptake amongst other effects (Besedovskyet al., 2012). Alterations in proinflammatory cytokines and anti-inflammatory cytokines are known to have enhancing and inhibitory effects on different aspects of sleep. These cytokines are thought to act on NREM sleep through an interaction with growth hormone-releasing hormone, prolactin and VIP (Diaz et al., 2013).

Studies on the white blood cell indices and by inference immune status of Nigerian health personnel (nurses) as a result of sleep deprivation consequent on night shift work has not been previously elucidated. Assessing these indices will help to guide in providing strategies in improving sleep health and the immune status of night shift workers.

II. Methodology

Study area

The study was carried out among students of the Department of Nursing Sciences undergoing their postings in various wards in the Ahmadu Bello University Teaching Hospital, Shika in the month of May, 2012. The teaching hospital is located in Zaria, Northern Nigeria. Which is located in the Northern Guinea Savannah (11 º 10' N, 07º 38 'E).

Study Subjects

Twenty one subjects comprising of ten (10) male and eleven (11) females participated in the study. They were students of Department of Nursing Sciences, Ahmadu Bello University, Zaria. They were all in their fourth year (400 level) and undergoing ward postings in different wards of the Ahmadu Bello University Teaching Hospital, Shika, The wards comprised of male & female surgical wards, special care baby unit, paediatric medical ward and the paediatric emergency unit). Recruited subjects were all Nigerian nursing students aged between 16 – 30 years. All participants were on night shift duty for the duration of the study which lasted five days. Subjects were excluded if they smoked, were on steroids, took alcohol, had an episode of fever within the last one week prior to the study, or had symptoms suggestive of an illness. Informed consent was obtained from the subjects prior to their participation in the study. Questionnaires were self- administered to eligible subjects while blood samples were collected for analysis.

Body mass index determination

Body weight was determined using a weighing scale (LLP/ AC Morgan and Sons, London) with the subject in light clothing to the nearest 0.2g. While the height of the subjects was measured using a stadiometer to the nearest 0.2cm with the subject standing on bare feet. The body mass index (BMI) was calculated as weight in kg/ height in m^2.

Blood collection

Two millilitres of blood was collected from the subjects via venepuncture using a sterile 5ml syringe. Blood was collected twice from the subjects. The first sample was collected at the commencement of the night shift between the hours of 21.00 and 23.00. A second sample was collected at the commencement of the night shift by day five of the night shift. The blood sample was transferred into EDTA bottles and stored in a refrigerator before analysis.

Sample analysis

Samples were analysed within 24 hours of blood collection. This was carried out in the laboratory of the Department of Human Physiology, Ahmadu Bello University, Zaria. White blood cell indices considered were white blood cell counts and differential white blood cell counts (neutrophil, oesinophil, basophil, monocyte and lymphocyte counts).

Determination of white blood cell count

The white blood cell pipette was used to draw a blood sample from the EDTA bottle to the 0.5 mark while the diluting fluid was drawn up to the 11 mark. The mixed sample was next transferred to a haemocytometer and the cells counted using a light microscope at X 10 magnification according to methods described by Lewis et al., 2008.

Determination of differential white blood cell count

A drop of blood from the EDTA bottle was placed on a clean dry slide a blood film made with a second slide. The dried blood film was air dried, stained with Leishman's stain, dried and mounted on the microscope for identification and cell counting according to methods described by Lewis et al., 2008.

Statistical Analysis: Results were presented as mean ± standard deviation and data analysed using paired t-test. A statistical significance of $p<0.05$ was selected.

III. Results

Table 1. Shows the mean age of the subjects as 23.24±2.50years. While their mean body mass index (BMI) was within normal range BMI (24.00±6.57kg/m^2). Table 2 showed there was a significant decrease in the total white blood cell count (5.41 ± 1.42 X 10^3/µLvs4.47 ± 0.97 X 10^3/µL) and differential neutrophil count (58.43 ± 9.00% vs47.10 ± 11.30%) of the sleep deprived night shift nurses while the differential lymphocyte count was significantly higher after sleep deprivation (33.38 ± 10.13% vs43.86 ±7.37%) . However, the decrease in differential basophil and monoocyte count and the increase in differential eosinophil count was not statistically significant.

Table 1. The mean ± S.D of the age and body mass index of the night shift nurses.

Variables	Mean ± SD
Age (years)	23.24±2.50
Weight (kg)	64.81±13.72
Height (cm)	165.57 ± 10.67
BMI (kg/m^2)	24.00±6.57

Table 2. The mean ± S.D of the total white blood cell count and differential white blood cell count of the subjects at the commencement of the night shift and after 4 days of night shift

VARIABLES	PRE-SLEEP DEPRIVATION	AFTER SLEEP DEPRIVATION
WBC (X 10^3/µL)	5.41±1.42	4.47±0.97*
DIFFERENTIAL NEUTROPHIL (%)	58.43 ±9.00	47.10±11.30*
DIFFERENTIAL LYMPHOCYTE (%)	33.38 ± 10.13	43.86 ±7.37*
DIFFERENTIAL OESINOPHILS (%)	2.44±1.16	2.57±1.48
DIFFERENTIAL MONOCYTES (%)	5.09 ± 1.74	5.00 ± 2.0
DIFFERENTIAL BASOPHILS (%)	0.52 ± 0.51	0.48 ± 0.51

*P< 0.05

IV. Discussion

The relationship between shift work (usually associated with sleep deprivation) and immune function has been a subject of interest (Sephton and Siegel, 2003).There is increasing evidence that there is an important interaction between sleep and the immune system. Disrupted or reduced sleep impairs the immune system while immune responses triggered by infection alter sleep patterns (AlDabal and BaHamman, 2011).

The changes in some white cell indices of student nurses on night shift was investigated in this study. Their night shift lasted 10 hours for five days as part of their training. They switched to a day time shift after a 48 hour interval.

The study revealed a significant lower white blood cell count and differential neutrophil count in the subjects after four days of night shift work (Table 2). Nagai et al., 2011, observed a similar effect in nurses performing shift work. They also observed a lower natural killer cell activity, lower $CD16^+$ and CD 56^+ cell count. The decrease in white blood cell count is said to be also fatigued related (Morikawaet al., 2005, Yasuda et al., 2001). This is more so since in between the night shifts the subjects had no adequate rest. Studies related to fatigue and sleepiness indicate that adults require 6 to 10 hours of sleep in a 24-hour period (Rogers, 2008). An increased mortality has been shown in individuals who sleep <4 hours or >10 hours nightly (Colten and Altevogt, 2006). Disturbances in biological circadian rhythms results in decreased secretion of melatonin, increased secretion of cortisol, increased blood pressure as well as induce changes in the rhythms of the Hypothalamic-Pituitary-Adrenal axis (Farautet al., 2011-b; Palma et al., 2007). These changes have been associated with the changes in immune function.

Everson (1993), reported a hypercatabolic state in sleep deprived rats which was associated with bacteremia due to a breakdown of host defence mechanism against opportunistic and pathogenic micro-organisms in the environment. The bacteraemia was not associated with a febrile response which suggests an immunosuppressed state with an eventual lethal septicaemia.

A decrease in differential neutrophil count was observed which proportionally, is the most abundant leukocyte subpopulation. Lower neutrophil counts are reported to be associated with a decreased ability to phagocytose (Palmbladet al., 1976). Contrary findings were observed by (Farautet al., 2011-a) where an increased neutrophil count, myeloperoxidase expression and IL-6 secretion was observed after sleep deprivation. Suggesting a low-level systemic inflammation after sleep deprivation or restriction.

Among leucocyte subsets, circadian rhythms of monocytes and lymphocytes have been shown to be significantly displaced by total sleep deprivation. For our study, sleep deprivation was partial and the increased lymphocyte count were similar to the findings of (Born et al., 1997). While the monocyte count for our subjects was decreased.

The decrease in immunologic defence among night shift workers is explained by a psychoneuroimmunological concept. The immune suppression depicted by decreased cell counts is related to increased cortisol concentration in blood secondary to stress as a result of sleep disruption but serum cortisol was not assayed in our study. These changes in immune function were found to be reversible with sleep recovery (Everson, 1993).

A study by Everson et al., 2008 showed contrary findings which consisted of increase in circulating leucocytes (predominantly granulocytes) with higher granulocytes location in the lungs and liver tissue; extravascular spaces. Increases in circulating cytokines, chemokines and immunoglobulins, which were ineffective, were demonstrated by an earlier study (Everson, 2005).

Metabolism, along with alertness and performance, are usually high during the day when the night shift worker is trying to sleep and low at night when the individual is trying to work. Improving sleep health in the shift system may enhance personnel health, work effectiveness and reduce its negative impact on immune defense (Foster and Wulff, 2005). A study related to fatigue and sleepiness indicate that adults require 6 – 10 hours of sleep in a 24 hour period (National Sleep Foundation, 2009). But most healthcare professionals, including nurses, typically receive little or no formal education about normal sleep or the essential role of sleep in maintaining adequate health and performance either during or after their training (Owens, 2005).

In conclusion, sleep deprivation in night shift nursing students was associated with a significant reduction in their mean white blood cell count and differential neutrophil count.

We recommend formal training on sleep health for health professionals and other personnel involved in shift work. Napping schedules should be incorporated into the shift schedule. Sleep recovery should also be encouraged amongst staff (it reverses most adverse effects of sleep deprivation).

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