UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL
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Ana Carolina Odebrecht Vergne de Abreu

ESTUDO RANDOMIZADO SOBRE O USO DE EQUIPAMENTOS DE PROTEÇÃO CONTRA A LUZ ARTIFICIAL NA RECUPERAÇÃO DE NEONATOS PREMATUROS

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Orientadora: Prof.ª Dr.ª Maria Paz Loayza Hidalgo
Co-orientadora: MSc. Melissa Alves Braga de Oliveira

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RESUMO

A vida na Terra evoluiu ao longo de bilhões de anos em ambientes predominantemente externos, sob condições ambientais cíclicas. Como consequência, complexos mecanismos fisiológicos de detecção e geração de ritmicidade desenvolveram-se. Para seres humanos, assim como para diversos organismos, variações de iluminação são a principal pista temporal externa capaz de sincronizar os ritmos biológicos ao ambiente. Entretanto, com o advento da eletricidade, seres humanos passaram a expor-se menos à luz natural durante o dia e mais à luz artificial durante a noite, o que traz consequências para a saúde. A iluminação em Unidades de Tratamento Intensivo Neonatais (UTIN) costuma ser contínua ou irregular, e neonatos ficam expostos à luz também no período noturno, o que pode impactar negativamente seu desenvolvimento até a alta hospitalar. Neste contexto, o objetivo deste trabalho foi avaliar o impacto do uso de equipamentos individuais de proteção contra a luz artificial no período noturno no desenvolvimento e crescimento de neonatos prematuros. Neonatos nascidos com menos de 37 semanas gestacionais que não necessitavam mais de cuidados intensivos constantes foram randomizados para utilizar protetores oculares no período noturno (grupo intervenção, n = 21) ou para continuarem expostos à luz artificial de baixa intensidade normalmente presente na unidade (grupo controle, n = 20). Foram avaliados o número de dias até a alta, ganho de peso diário e sinais vitais (frequência cardíaca, frequência respiratória, saturação de oxigênio e temperatura corporal) a cada 6 horas (02:00, 08:00, 14:00 e 20:00). Neonatos que utilizaram protetores oculares à noite receberam alta mais cedo do que bebês do grupo controle (8 [5] dias vs 12 [3.75] dias; $p < 0.05$). Não foi observada diferença significativa entre os grupos com relação ao ganho de peso. Uma maior variação de frequência cardíaca foi observada no grupo intervenção, com valores menores de batimentos por minuto (bpm) às 14:00 e às 20:00. Não foram detectadas diferenças significativas nas medidas de frequência respiratória, saturação de oxigênio e temperatura corporal entre os grupos nos horários avaliados. As atividades realizadas na UTI neonatal e em outras unidades de terapia intensiva tornam inviável a implementação de um ambiente completamente escuro em qualquer momento do dia. A partir dos resultados encontrados no presente estudo e dos dados presentes na literatura, consideramos que unir um ambiente escurecido à noite com dispositivos individuais de proteção contra a luz seja uma forma de criar melhores condições para o desenvolvimento de bebês prematuros na UTIN. Além disso, a utilização de protetores oculares no período noturno é uma intervenção barata que pode reduzir os custos da internação ao diminuir o número de dias até a alta hospitalar, gerando uma economia para o sistema público de saúde.

Palavras-chave: Unidade de Tratamento Intensivo Neonatal, neonatos prematuros, cronobiologia, poluição luminosa, protetor ocular, neonatologia

ABSTRACT

Life on Earth has evolved over billions of years in predominantly external environments, under cyclical conditions. As a consequence, complex physiological mechanisms for detecting and generating rhythmicity were developed. For human beings, as well as for several organisms, lighting variations are the main external temporal cue capable of synchronizing biological rhythms to the environment. However, with the advent of electricity, humans' exposure to natural light during the day diminished and the exposure to artificial light at night increased, which has health consequences. Lighting in Neonatal Intensive Care Units (NICU) is usually continuous or irregular, and infants are also exposed to light at night, which can negatively impact their development until hospital discharge. In this context, the objective of this work was to evaluate the impact of the use of individual equipment for protection against artificial light at night on the development and growth of preterm neonates. Infants born at less than 37 weeks of gestation who no longer needed constant intensive care were randomized to either use eye protection at night (intervention group, n = 21) or to remain exposed to the low-intensity artificial light normally present in the unit (control group, n = 20). Number of days until discharge, daily weight gain and vital signs (heart rate, respiratory rate, oxygen saturation and body temperature) were evaluated every 6 hours (02:00, 08:00, 14:00 and 20:00). Neonates who used eye protection at night were discharged earlier than babies in the control group (8 [5] days vs 12 [3.75] days; $p < 0.05$). There was no significant difference between groups with regard to weight gain. A greater variation in heart rate was observed in the intervention group, with lower values of beats per minute (bpm) at 14:00 and 20:00 pm. There were no significant differences in the measurements of respiratory rate, oxygen saturation and body temperature between the groups at the evaluated times. The activities performed in the neonatal ICU and other intensive care units make it impossible to implement a completely dark environment at any time of the day. Based on the results found in the present study and the data present in the literature, we consider that combining a darkened environment at night with individual light protection devices is a way of creating better conditions for the development of premature infants in the NICU. In addition, the use of eye protectors at night is an affordable intervention that can reduce the costs of hospitalization by reducing the number of days until hospital discharge, generating savings for the public health system.

Keywords: Neonatal Intensive Care Unit, preterm infants, chronobiology, light pollution, light protection equipment, neonatology

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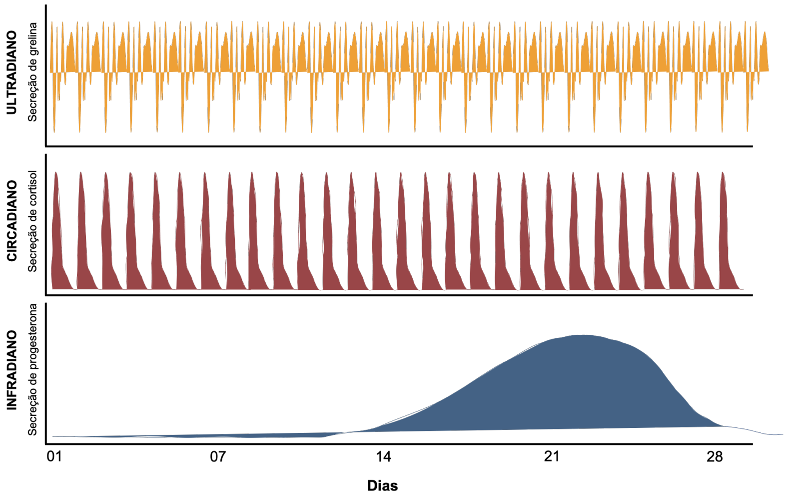
1 INTRODUÇÃO COMPREENSIVA

Cronobiologia: o estudo dos ritmos biológicos

Desde o surgimento do primeiro ser vivo, há quase 4 bilhões de anos, a vida na Terra vem evoluindo sob condições ambientais cíclicas. Os movimentos de rotação e translação do planeta dão origem, por exemplo, a dias claros e noites escuras, a variações diárias e anuais de temperatura e a eventos climáticos sazonais. Neste contexto, a capacidade dos organismos de identificar e prever alterações no meio em que se encontram representou uma vantagem evolutiva, possibilitando uma melhor adaptação ao ambiente e, consequentemente, maiores chances de sobrevivência. Como resultado, mecanismos cada vez mais complexos para detectar e gerar ritmicidade se desenvolveram e, atualmente, sabe-se que os mais diversos organismos (desde bactérias, fungos e algas até plantas, moscas, aves e mamíferos) apresentam algum tipo de sistema temporizador (BELL-PEDERSEN *et al.*, 2005).

A Cronobiologia é a ciência que estuda os ritmos biológicos. Estes podem ser classificados em ultra-, infra- ou circadianos de acordo com a sua duração: ritmos circadianos possuem duração de cerca de um dia, mais especificamente entre 20-28 horas (ex.: temperatura corporal, liberação de cortisol, ciclo sono-vigília); ritmos ultradianos ocorrem mais de uma vez por dia, ou seja, apresentam duração menor que 20 horas (ex.: batimentos cardíacos, respiração); e ritmos infradianos ocorrem menos de uma vez por dia, ou seja, apresentam duração maior que 28 horas (ex.: ciclo menstrual) (VITATERNA; TAKAHASHI; TUREK, 2001). A **Figura 1** apresenta uma comparação entre ritmos ultra-, infra- e circadianos.

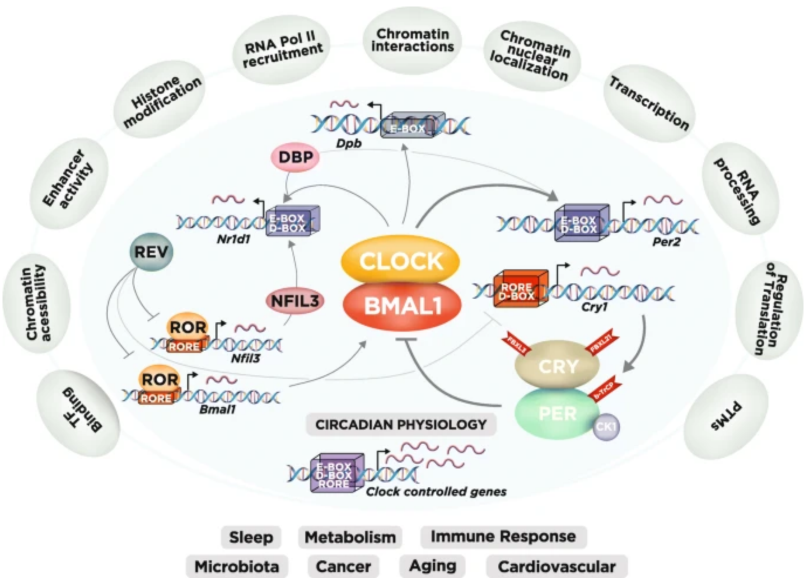
Figura 1. Exemplos de ritmos biológicos



Fonte: elaborada pela autora.

Segundo Takahashi (TAKAHASHI, 2017), o mecanismo molecular dos relógios circadianos em mamíferos é gerado por um circuito de retroalimentação transcricional autorregulado em cada célula. Os genes envolvidos nesse processo são chamados de “genes do relógio” (*clock genes*), e os principais são *Clock*, *Bmal1*, *Per1*, *Per2*, *Cry1* e *Cry2*. Os fatores CLOCK e BMAL1 ativam a transcrição dos genes Per e Cry, cujos produtos, por sua vez, inativam os fatores CLOCK e BMAL1. Conforme as proteínas PER e CRY são degradadas, CLOCK e BMAL1 voltam a promover a transcrição. Este ciclo ocorre em um período de cerca de 24 horas (TROTT; MENET, 2018). Os fatores de transcrição e elementos de resposta mencionados, somados a outros, afetam a expressão de diversos genes e regulam o funcionamento celular (RIJO-FERREIRA; TAKAHASHI, 2019) (**Figura 2**).

Figura 2. A rede de genes circadianos e camadas de regulação do genoma em mamíferos

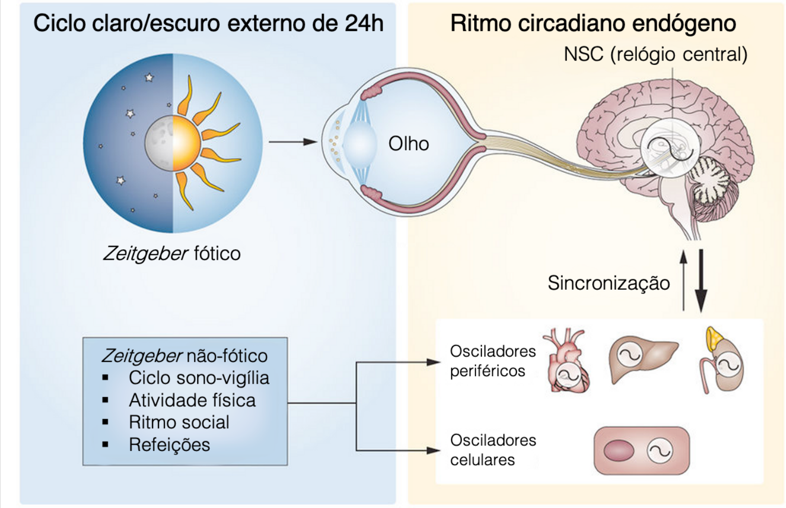


Os fatores de transcrição CLOCK e BMAL1 ativam os genes *Per1*, *Per2*, *Cry1* e *Cry2* (*Per2* e *Cry1* são mostrados na figura como exemplos), cujos produtos proteicos (PER e CRY) reprimem sua própria transcrição através da inibição do complexo CLOCK:BMAL1. As proteínas PER e CRY são reguladas pós-tradução pelas vias paralelas da ubiquitina ligase E3 (FBXL3 e FBXL21 para CRY e β-TrCP para PER), com os níveis de PER também regulados por CK1. CLOCK e BMAL1 também regulam a expressão dos genes *Nr1d1/2*, que codificam os receptores nucleares REV-ERBα/β, respectivamente. Esses receptores nucleares reprimem ritmicamente a transcrição de *Bmal1* e *Nfil3*, dois genes que são ativados pelo receptor órfão-α/β relacionado ao ácido retinóico (RORα/β). Por sua vez, NFIL3 juntamente com a proteína de ligação D-box (DBP), bem como CLOCK e BMAL1, regulam o ritmo dos receptores nucleares REV-ERBα/β. Esses três loops de feedback transcricional interligados regulam a maioria dos genes cíclicos, levando a ritmos em vários sistemas fisiológicos diferentes, do sono ao metabolismo e envelhecimento (parte inferior da figura). Observe que os motivos E-box e D-box e as regiões de ligação de RORE estão em cis a montante no promotor; no entanto, eles são representados aqui como uma caixa empilhada para simplificação. Um trabalho recente identificou níveis adicionais de regulação da expressão gênica circadiana (camada externa da figura), incluindo modificações rítmicas de histonas, recrutamento de RNA polimerase II (Pol II), interações de conformação cromossômica circadiana e modificações pós-tradução (PTMs). Fonte: Rijo-Ferreira e Takahashi, 2019.

Variações de iluminação como pista temporal

O sistema circadiano é regulado tanto internamente quanto por meio de pistas externas, chamadas de *Zeitgebers* (do alemão, "doador de tempo"). Horários de alimentação, atividade física e interação social são exemplos de possíveis pistas temporais (MONK, 2010); o *Zeitgeber* mais potente, no entanto, é o fótico. Ou seja, as variações de iluminação são a principal pista externa capaz de sincronizar nossos ritmos ao ambiente (BUTTGEREIT *et al.*, 2015). Isso acontece pois, em mamíferos, o sistema temporizador circadiano é regido pelo núcleo supraquiasmático (NSQ) do hipotálamo, considerado o relógio central, ou marcapasso central (HASTINGS; REDDY; MAYWOOD, 2003). Estímulos fóticos provenientes do ambiente são percebidos pelas células ganglionares intrinsecamente fotossensíveis da retina (ipRGCs) que se projetam através do trato retino-hipotalâmico até o NSQ e este, por sua vez, sincroniza os ritmos dos relógios periféricos distribuídos por todo o organismo, como um maestro regendo uma orquestra (RICHTER *et al.*, 2004) (**Figura 3**). Uma das estruturas que recebe informações do NSQ é a glândula pineal, que na ausência de luz produz e secreta melatonina, um hormônio que, entre outras funções, promove a indução e a manutenção do sono (MOORE, 1997). Já na presença de luz, a síntese e a liberação de melatonina são inibidas e o organismo tende a acionar mecanismos que aumentam a frequência cardíaca, a temperatura corporal e a produção de cortisol (MARQUES; MENNA-BARRETO, 1997).

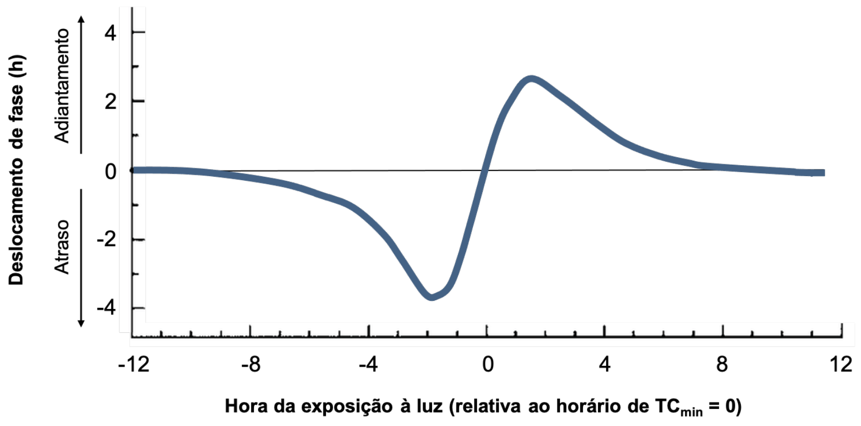
Figura 3. Relógios circadianos internos e *Zeitgebers* externos



Fonte: adaptado de Buttgereit *et al.*, 2015.

O sistema circadiano representa uma vantagem evolutiva por ser uma forma de adaptação ao ambiente, no qual se observa variações de temperatura de cor e intensidade luminosa ao longo de 24 horas. O horário de exposição a estímulos luminosos é capaz de alterar a fase dos ritmos circadianos, adiantando-os ou atrasando-os. Estes deslocamentos de fase são avaliados com base em marcadores como a temperatura corporal mínima, o horário de início da liberação de melatonina em condições de luz fraca (DLMO, *dim light melatonin onset*) e o ponto médio do perfil de melatonina (REVELL; EASTMAN, 2005). A exposição à luz no período da manhã leva a um adiantamento de fase (EASTMAN *et al.*, 2005; MISIUNAITE; EASTMAN; CROWLEY, 2020; ROSENTHAL *et al.*, 1990) e, no período da noite, a um atraso de fase (LACK, L.; WRIGHT, 1993; YOUNGSTEDT *et al.*, 2016). Este fenômeno pode ser ilustrado através de uma curva de resposta de fase (do inglês, *phase response curve*), como a representada na **Figura 4**.

Figura 4. Curva de resposta de fase



Representação da curva de resposta de fase após exposição à luz. Quando a exposição ocorre antes do horário em que a temperatura corporal atinge seu mínimo (TC_{min}), há um atraso de fase. Quando ocorre após o horário de TC_{min}, há um adiantamento de fase (LACK, Leon; WRIGHT, 2007). Fonte: elaborada pela autora.

Com o advento da eletricidade, a exposição do ser humano à iluminação foi alterada. Atualmente, em países industrializados, as pessoas passam a maior parte do dia em ambientes internos (KLEPEIS *et al.*, 2001; LEECH *et al.*, 2002; SCHWEIZER *et al.*, 2007), onde a principal fonte de luz costuma ser artificial, ou seja, menos intensa e mais constante do que a luz solar. A exposição à luz continua durante o período da noite, através de lâmpadas, televisores, computadores, celulares e outros eletrônicos, possibilitando inclusive o trabalho noturno, que envolve cerca de 8% da população empregada no Brasil (IBGE – INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA, 2019). Como a alteração dos padrões de iluminação a que os seres humanos estão expostos é uma mudança recente, as consequências para a saúde ainda não são totalmente compreendidas, mas estão se tornando cada vez mais evidentes (EVANS; DAVIDSON, 2013).

Alterações de iluminação e saúde

Diversos estudos relacionam exposição excessiva à iluminação artificial, pouca exposição à luz natural e alterações de intensidade, duração e temperatura de cor da luz com desfechos de saúde negativos (BECHTOLD; GIBBS; LOUDON, 2010; DAUCHY *et al.*, 2015; HAUS; SMOLENSKY, 2013). Um estudo com funcionárias do Hospital de Clínicas de Porto Alegre mostrou que aquelas que trabalhavam em locais sem janelas e com menor exposição à luz natural apresentaram maiores níveis de cortisol e menores níveis de melatonina à noite do que funcionárias de locais com janelas. O cortisol elevado foi positivamente correlacionado com sintomas depressivos e distúrbios psiquiátricos menores; e a melatonina diminuída foi correlacionada com sintomas depressivos e pior qualidade de sono (HARB; HIDALGO; MARTAU, 2015). Além disso, pessoas internadas em unidades de tratamento intensivo (UTIs) estão constantemente expostas à luz, barulho e atividade, com poucas pistas que ajudem a distinguir entre dia e noite. Estes pacientes frequentemente sofrem *delirium*, um quadro caracterizado por confusão mental, dificuldade de raciocínio, agitação, comportamento agressivo e alucinações (GIRARD; PANDHARIPANDE; ELY, 2008). Um estudo de 1972 comparou pacientes internados em UTIs com e sem janelas, e foi observado que pacientes na UTI sem janelas, que não estavam expostos a uma variação natural de iluminação, estavam mais propensos a desenvolver o quadro (WILSON, 1972).

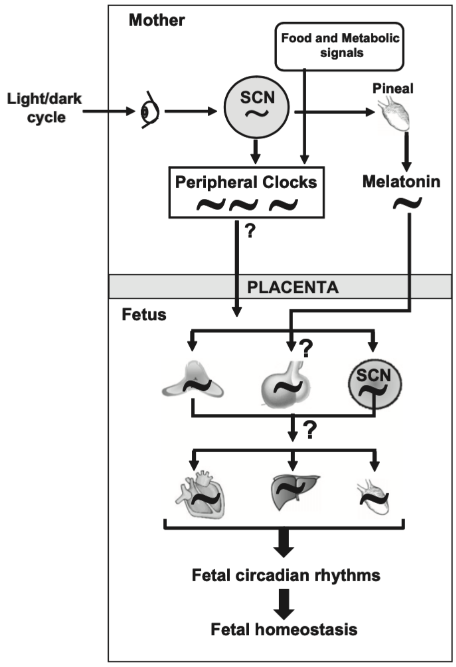
Quando a exposição à luz artificial ocorre no período noturno, além da supressão da melatonina podem ocorrer atrasos de fase no relógio circadiano, levando a um aumento do nível de alerta à noite e a uma possível privação de sono. Um exemplo clássico do efeito da exposição à luz artificial durante a noite na saúde é a observação, por meio de estudos epidemiológicos, de que trabalhadoras noturnas possuem maior risco de desenvolver câncer de mama (DAVIS; MIRICK; STEVENS, 2001; MANOUCHEHRI *et al.*, 2021; MEGDAL *et al.*, 2005). Os mecanismos por trás do potencial carcinogênico do trabalho de turno estão sob investigação e, recentemente, a desregulação circadiana de genes de reparo do DNA foi demonstrada em um estudo controlado em laboratório com simulação de trabalho noturno (KORITALA *et al.*, 2021). As evidências também apontam para uma predisposição para sobrepeso, obesidade e distúrbios metabólicos em trabalhadores noturnos, que pode ser resultado de uma disrupção dos ritmos circadianos (NELSON; CHBEIR, 2018). Mesmo entre pessoas que não trabalham à noite, as chances de desenvolver obesidade aumentam conforme aumenta a exposição à luz artificial no período noturno (MCFADDEN *et al.*, 2014).

O sistema circadiano de recém-nascidos

Os resultados presentes na literatura indicam que, mesmo em adultos, que passaram décadas desenvolvendo um ritmo circadiano endógeno, este pode ser facilmente perturbado por alterações ambientais. Bebês recém-nascidos, no entanto, possuem um sistema temporizador ainda imaturo e dependem inteiramente de pistas externas para sincronizar seus ritmos, que mudam dramaticamente durante o primeiro ano de vida (THOMAS *et al.*, 2014).

Durante a gestação, o feto apresenta ritmos circadianos de frequência cardíaca, movimentação e hormônios que são regulados pelos ritmos da progenitora. Variações de temperatura corporal, secreção de melatonina (um dos poucos hormônios que atravessam a placenta sem sofrer alterações), fluxo de nutrientes e ciclos de atividade e repouso da mãe atuam como pista temporal para organizar os ritmos fetais (SERON-FERRE; VALENZUELA; TORRES-FARFAN, 2007) (**Figura 5**). Estudos apontam que o trabalho de turno (que pode levar à disrupção dos ritmos circadianos) durante a gravidez aumenta o risco de nascimento prematuro, de o recém-nascido ser pequeno para idade gestacional e de desfechos reprodutivos adversos (HAZELHOFF *et al.*, 2021), resultados que ressaltam a influência dos ritmos maternos no desenvolvimento fetal.

Figura 5. Representação esquemática das vias de sincronização propostas do sistema circadiano fetal



A adrenal fetal de ratos e o NSQ (SCN) fetal de primatas podem ser controlados pelos ritmos da melatonina materna, enquanto outros relógios periféricos fetais têm sua fase sincronizada por: (1) o NSQ materno, por meio de sinais humorais ou metabólicos que cruzam a placenta ou (2) um relógio circadiano periférico fetal (potencialmente a glândula adrenal fetal, por meio da produção circadiana de glicocorticóides). Fonte: Serón-Ferré *et al.*, 2012.

Após o nascimento, as pistas temporais que o neonato recebia no ambiente uterino cessam e seu sistema circadiano imaturo ainda não é capaz de gerar e sustentar ritmos de 24h endógenos (THOMAS *et al.*, 2014). Padrões de alimentação e interação social se tornam, consequentemente, importantes sincronizadores dos ritmos e, assim como em adultos, as variações ambientais de iluminação também são potentes *Zeitgebers* para neonatos. Estudos em primatas não humanos indicam que o NSQ responde à luz a partir de um estágio equivalente a 24 semanas de gestação em humanos, sugerindo que a iluminação também pode atuar sobre os ritmos de bebês nascidos prematuros (HAZELHOFF *et al.*, 2021). De fato, quando comparou-se o efeito de iluminação cíclica (acesa durante o dia e desligada durante a noite) versus não-cíclica (iluminação artificial constante) no crescimento e desenvolvimento de prematuros internados em uma UTI neonatal, foi observado que bebês expostos à iluminação cíclica eram mais ativos durante o dia do que à noite – uma indicação de ritmicidade circadiana (MILLER *et al.*, 1995). Ainda nesta linha, Vásquez-Ruiz e colegas observaram que prematuros internados em uma UTI neonatal submetidos a um ciclo claro/escuro apresentaram ganho mais rápido de peso, melhor saturação de oxigênio, frequência cardíaca mais estável e menor tempo até a alta do que neonatos que permaneceram sob iluminação artificial constante (padrão da Unidade) (VÁSQUEZ-RUIZ *et al.*, 2014).

Estudos que introduzem um padrão de iluminação cíclico geralmente realizam mudanças no sistema de iluminação da unidade ou, eventualmente, utilizam capacetes individuais (VÁSQUEZ-RUIZ *et al.*, 2014), cortinas (GUYER *et al.*, 2012) ou cobertores de incubadoras (BRANDON; HOLDITCH-DAVIS; BELYEA, 2002; GUYER *et al.*, 2012) para bloquear a luz. Estes métodos alcançam o objetivo proposto de criar uma variação de iluminação entre o dia e a noite, com noites mais escuras do que os dias. Entretanto, durante a noite continua havendo exposição à luz, mesmo que de baixa intensidade (~ 25 lx) (GUYER *et al.*, 2012; VÁSQUEZ-RUIZ *et al.*, 2014). Estudos em adultos apontam que uma iluminância de 5 lx já é suficiente para reduzir a síntese da melatonina significativamente, e mesmo 1 lx resulta em piora na qualidade do sono (STEBELOVA; ROSKA; ZEMAN, 2020). Visto que uma iluminação que permita a visibilidade é necessária durante todo o tempo em UTIs, o uso de dispositivos individuais de proteção contra a luz artificial à noite, como máscaras para os olhos (**Figura 6**), representam uma solução em potencial para o problema da poluição luminosa.

Figura 6. Protetor ocular para fototerapia

Fonte: Impacto Medical. Disponível em <https://impactomedical.com.br/baby-block/> Acesso em abr. 2021.

1.1 JUSTIFICATIVA

As evidências obtidas até agora no campo da pesquisa biomédica demonstram o impacto da iluminação na regulação da nossa fisiologia. Além disso, sugerem o potencial terapêutico de sistemas de proteção individual à poluição luminosa noturna no intuito de minimizar os efeitos deletérios que a exposição excessiva à luz durante a noite tem sobre o nosso organismo. Nesse sentido, nossa hipótese é de que neonatos prematuros que utilizarem proteção contra a luz artificial no período noturno terão ganho de peso mais acelerado e permanecerão menos tempo na ala de internação, se comparados aos neonatos expostos à luz artificial durante a noite.

1.2 OBJETIVOS

1.2.1 Objetivo geral

Verificar os efeitos da proteção contra a luz artificial no período noturno no ganho de peso e no tempo de internação de neonatos prematuros do Hospital Nossa Senhora de Pompéia de Caxias do Sul.

1.2.2 Objetivos específicos

- Verificar a influência da máscara de proteção individual à iluminação noturna no tempo de internação de neonatos prematuros;
- Avaliar o ganho de peso de neonatos que utilizam máscaras que oferecem proteção individual à iluminação noturna, comparados a neonatos sem máscaras;
- Caracterizar o ambiente e registrar fatores ambientais como intensidade de iluminação, tempo de exposição à luz acesa e apagada, temperatura e umidade do ar, através de aparelhos medidores específicos instalados na unidade;
- Verificar o padrão de alimentação de neonatos prematuros que utilizam máscaras que ofereçam proteção individual à iluminação noturna, comparados a neonatos sem máscaras;
- Verificar evolução clínica por monitoramento de sinais vitais de neonatos prematuros que utilizam máscaras que ofereçam proteção individual à iluminação noturna.

2 ARTIGO CIENTÍFICO

USE OF LIGHT PROTECTION EQUIPMENT AT NIGHT REDUCES TIME UNTIL DISCHARGE FROM THE NICU

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ABSTRACT

Newborn infants have an immature circadian system and relay on external temporal clues for synchronizing their biological rhythms to the environment. In Neonatal Intensive Care Units (NICU), lighting is usually continuous or irregular and infants are exposed to artificial light at night, which can have negative health consequences. Therefore, the aim of this study was to evaluate the impact of the use of individual light protection equipment at night on the development and growth of preterm neonates. Infants born at less than 37 gestational weeks who no longer needed constant intensive care were admitted into a newborn nursery and randomized to either use eye masks at night (intervention, n = 21) or not (control, n = 20). Number of days until discharge, daily weight gain and vital signs were analyzed. Infants who used eye protection at night were discharged earlier than those in the control group (8 [5] days vs 12 [3.75] days; $p < 0.05$). There was no significant difference in weight gain between groups. A greater variation within the day in heart rate was observed in the intervention group, with lower values of beats per minute (bpm) at 2:00 pm and 8:00 pm. In light of our results and of previous findings present in the literature, we suggest that combining a darkened environment at night with individual light protection devices creates better conditions for the development of preterm infants in the NICU. In addition, eye masks are an affordable tool that can reduce hospitalization costs by decreasing the number of days spent in the NICU.

Keywords: Neonatal Intensive Care Unit, preterm infants, light pollution, light protection equipment, neonatology

INTRODUCTION

Preterm birth is defined by the World Health Organisation (WHO) as delivery before the completion of 37 gestational weeks (Vogel et al., 2018). Worldwide, approximately 15 million infants are born prematurely every year, with varying rates among countries that range from 5% to 18% of total births (World Health Organization et al., 2012). Premature infants are at higher risk of neonatal respiratory and neurological conditions, sepsis, visual and hearing problems and poorer neurodevelopmental outcomes (Vogel et al., 2018). Furthermore, preterm birth complications are the leading cause of mortality of children under the age of five (Harrison and Goldenberg, 2016). Given that specialized care is critical during the first weeks or months of a preterm infant's life, when proper health infrastructure is available, the newborns are admitted to a Neonatal Intensive Care Unit (NICU). In this environment, infants are often exposed to constant lighting conditions and artificial light at night (ALAN) (Hazelhoff et al., 2021).

During the gestational period, maternal circadian signals, such as temperature variations, activity-rest cycle, feeding schedule and melatonin secretion are responsible for entraining fetal rhythms (Serón-Ferré et al., 2012). After delivery, in the absence of these maternal signals and with an immature circadian system, the newborn uses social interaction patterns, feeding schedule and, especially, environmental light variations as timing cues (Thomas et al., 2014). The light-dark cycle is the main external clue responsible for the entrainment of circadian rhythms (Duffy and Wright, 2005). In adults, lighting variations are perceived by intrinsically photosensitive ganglion cells in the retina, which send this information to the suprachiasmatic nucleus of the hypothalamus (SCN) through the retinohypothalamic tract (RHT). The SCN acts as a master clock, synchronizing peripheral circadian oscillators present in the whole organism (Bedrosian and Nelson, 2013). Although it is currently unknown in which developmental stage the RHT becomes functional in humans, studies in non-human primates indicate that the SCN is responsive to light since the equivalent to 24 weeks of gestation in humans (Hao and Rivkees, 1999), suggesting that lighting can also influence the rhythms of premature infants.

In fact, several studies documented improvement in clinical outcomes of preterm infants exposed to light-dark cycles in NICUs, when compared to the typical constant light or constant near-darkness conditions (Hazelhoff et al., 2021). When timed correctly, the exposure to bright light can synchronize the circadian clock to the external environment, regulating behavior and physiology (LeGates et al., 2014). Exposure to ALAN, on the other hand, has been associated in adults with several negative health outcomes, such as psychiatric and metabolic disorders and higher cancer risk (Bechtold et al., 2010; Dauchy et al., 2015; Haus and Smolensky, 2013). The mechanisms behind these effects are not yet fully elucidated, but potentially include the suppression of melatonin biosynthesis, sleep deprivation and circadian disruption (Koritala et al., 2021; Nelson and Chbeir, 2018; Touitou et al., 2017). Because some light is necessary in the NICU (and other intensive care facilities) at all times for visibility reasons, creating a completely dark environment during the night is often not a possibility. Studies in adults indicate that exposure to even very low levels of artificial light at night (<10 lx) can interfere with melatonin biosynthesis, alter sleep structure and aggravate sleep quality (Cho et al., 2016; Phillips et al., 2019; Stebelova et al., 2020; Tähkämö et al., 2019). The use of individual light protection equipment, such as eye masks, offer a potential solution to this problem (Hu et al., 2010). In this context, the aim of the present study was to investigate the impact of the use of individual light protection equipment at night on the development and growth of preterm infants.

MATERIALS AND METHODS

Participants

The sample consisted of forty-one infants born under 37 gestational weeks (average gestational age of 31.99 ± 2.09 weeks) that no longer required intensive care and were admitted at a nursery adjacent to the NICU. The eligibility criteria of the study were the same as those used for admission in the room: weight greater than 1500g and stability of vital signs for at least 48 hours. Infants with congenital malformation relevant to the measurement of the desired outcomes (e.g., pre-chiasmatic blindness, brain, cardiac and digestive tract malformations), O2-dependency due to bronchopulmonary dysplasia and previous therapeutic phototherapy were not included.

The randomization was performed as follows: prior to the start of the study, the research team determined that infants in the control group would be identified by numbers 1-20 and those in the intervention group, by numbers 21-41. The numbers were then randomized by a computer to generate the order in which participants would be included (eg. the first infant included in the study would receive the number 37 and therefore be part of the intervention group). Envelopes containing information of which group the infant should be assigned to were labeled in the randomized order and sealed. Every time a participant was included in the study, the next envelope in line was opened by the NICU staff and the infant was allocated accordingly. Infants in the control group were exposed to the typical lighting conditions of the nursery during day and night, while those in the intervention group wore eye masks during the night. Twins were included and each infant was randomly assigned to the intervention (n = 6) or control (n = 4) group, meaning that siblings could either be assigned to the same group or not.

The study was conducted following the Declaration of Helsinki (World Medical Association, 2013) and was approved by the Research Ethics Committees of Hospital de Clínicas de Porto Alegre and Hospital Pompéia (CAAE 65311417.9.1001.5327). Verbal informed consent was provided by a legal guardian.

Eye masks

Infants in the intervention group were blindfolded from 19:00 to 07:00 with an eye protector typically used for phototherapy (Baby Block, Impacto Medical, Brazil). In the case a mother came to breastfeed after 19:00, the eye mask was removed during breastfeeding to allow eye contact between mother and child.

Setting

The study took place in a five-bed newborn nursery adjacent to the NICU. The room has three windows facing other indoor facilities (one facing a corridor and two facing the nursing station) and no external windows (see Fig. 1). Light was provided by two ceiling luminaires with dimmable eco halogens light bulbs (2700K) that were mostly on and four fluorescent lamp fixtures (4000K) that were only switched on if necessary, such as in the case of a medical emergency. Decisions regarding when lights were switched on, dimmed or switched off were made by the nurse or nurse technician in charge of the room.

[insert Figure 1.]

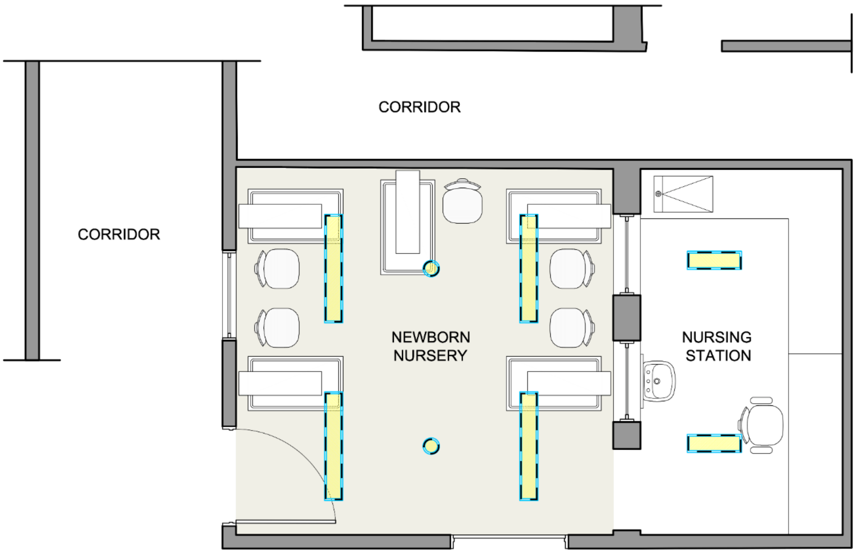

Figure 1. Architectural plan of the five-bed newborn nursery where the study took place. The location of the luminaires is shown in dashed lines.

Illuminance, temperature and humidity were measured every 10 minutes for 15 consecutive days by a sensor developed by the Biomedical Engineering Department of Hospital de Clínicas de Porto Alegre. The sensor was attached horizontally to a wall (i.e. facing the opposite wall) near the height of the head of an infant's bed, at 92 cm from the ground. The average temperature in the room was 24.9 ± 0.78 ºC and the average humidity was 62.73 ± 6.28%. The median of illuminance detected during the day (from 07:00 to 19:00) was 1.06 [2.13] lx but varied greatly, ranging from 0 to 46.54 lx on a few occasions. Small peaks were evident around feeding times during the day (08:00, 11:00, 14:00, 17:00, 20:00 and 23:00) (see Fig. 2). At night, the median of illuminance was 0.65 [1.26] lx and ranged from 0 to 47.42 lx.

[insert Figure 2.]

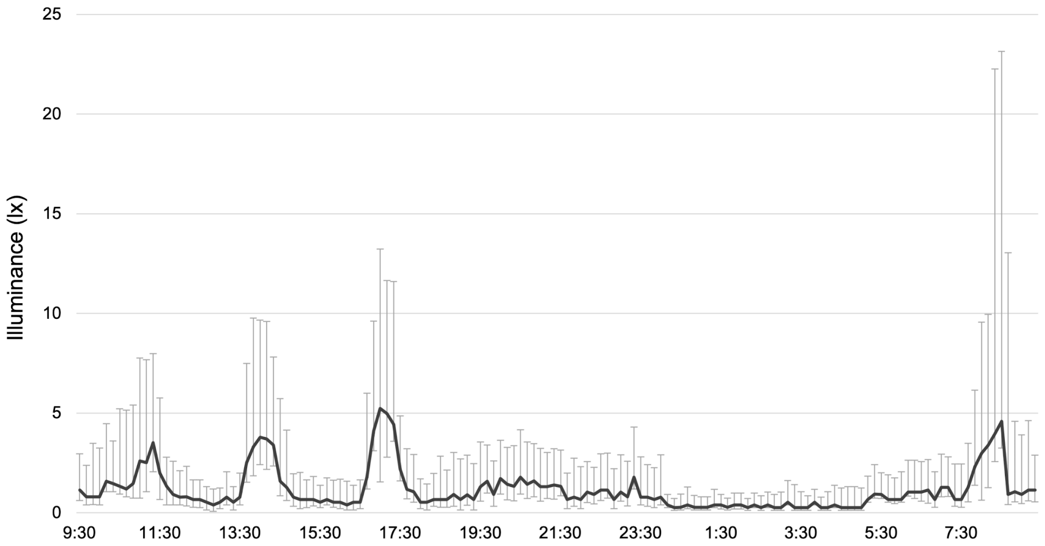

Figure 2. Daily profile of illuminance. Medians of illuminance (in lux) and interquartile range are presented according to clock time.

Measures

Days until discharge

The number of days spent in the room until discharge was considered our primary outcome. Discharge criteria included stable weight gain (15-30 g per day), weight greater than 1900g; the removal of the orogastric tube and complete oral feeding established for at least 48 hours; and the absence of other health conditions that required constant supervision.

Weight gain

Infants were weighed daily by a nurse or nurse technician. Body weight gain per day was calculated dividing the total weight gain by the number of days until discharge. Because weight can vary according to postmenstrual age (PMA) and sex of the infant, weight Z-scores were calculated using PediTools (Chou et al., 2020).

Vital signs

Heart and respiratory rate, blood-oxygen saturation and body temperature were measured every 6 hours (02:00, 08:00, 14:00 and 20:00) by the nurses using patient monitors (DX 2023, Dixtal Biomédica, Brazil; and Efficia CM120, Philips, Brazil).

Statistical analyses

Measures of age, sex, weight, head circumference and body length at birth, days until oral feeding and days until discharge were compared between groups using chi-square, Student's t or Mann-Whitney U tests when appropriate. Variations of heart rate and body temperature over time were analyzed by generalized estimated equations (GEE). Differences between groups at each time point were assessed by Bonferroni's test for pairwise comparisons and statistical significance for multiple-factor interactions was set at $p < 0.1$. Data were presented as mean ± SD, median [IQR] or percentage and statistical significance was set at $p < 0.05$ for the remaining tests. Analyses were performed on SPSS Statistics Subscription (IBM Corp., Armonk, NY, USA) and RStudio version 1.3.1056 (RStudio, PBC, Boston, MA, USA). Graphs were made on SPSS, RStudio and Microsoft Excel version 16.47 (Microsoft Corp., Redmond, WA, USA).

RESULTS

A total of 41 infants were included in the study between November 2017 and January 2021, 21 of which were randomized into the intervention group. No loss or exclusion occurred after randomization. Groups were similar in age and weight at birth, at the time of enrollment and at discharge. A summary of sample characteristics can be found in Table 1.

Table 1 Characteristics of the study population

	Intervention (n = 21)	**Control (n = 20)**	**Test contrast, p**
GA (wk)	32.86 [1.65]	31 [3.65]	U = 255, p = 0.24
Sex (% female)	57.14	35.00	χ2 = 2.02, p = 0.16
Birth weight (g)	1686.67 ± 339.42	1631.5 ± 340.75	*t* = -0.519, p = 0.61
Birth weight (Z-score)	-0.3 ± 0.87	-0.18 ± 0.97	*t* = 0.425, p = 0.67
Birth length (cm)	40.76 ± 2.88	40.29 ± 2.57	*t* = -0.545, p = 0.59
Head circumference at birth (cm)	30 [2]	28 [3.5]	U = 225, p = 0.2
PMA at check-in (wk)	34.57 [2]	34.07 [2.11]	U = 229, p = 0.62
Weight at check-in (g)	1873.33 ± 203.23	1883.75 ± 188.29	*t* = 0.170, p = 0.87
Weight at check-in (Z-score)	-1.03 [1]	-0.98 [1.37]	U = 204, p = 0.88
PMA at discharge (wk)	35.57 [1.72]	35.79 [1.64]	U = 192, p = 0.64
Weight at discharge (g)	2090 [362.5]	2215 [336.25]	U = 151, p = 0.12
Weight at discharge (Z-score)	-1.01 [1.04]	-1 [1.34]	U = 199.5, p = 0.78
Days until oral feeding (d)	6 [4.5]	8 [7.5]	U = 138.5, p = 0.06
Days until discharge (d)	8 [5]	12 [3.75]	U = 124.5, p < 0.05

Chi-square (χ^2), Mann-Whitney (U) or Student's *t*-test was used as appropriate.
Data are presented as median [IQR], mean ± SD or percentage.
GA: gestational age; PMA: postmenstrual age.

Days until discharge

Infants stayed a median of 11 [7.5 - 13] days in the nursery. Preterm infants randomized to the intervention group were discharged earlier than infants in the control group (control, 12 [10.25 - 14]; intervention, 8 [7 - 12]; Mann-Whitney U test = 124.5, $p = 0.025$) (Fig. 3). The calculated effect size was intermediate to large ($\eta^2 = 0.121$). Two infants stayed in the room much longer than the others, one from the control group (29 days) and one from the intervention group (35 days). If removed from the sample, the significant difference between groups was maintained, therefore we decided to include them in the remaining analyses.

[insert Figure 3.]

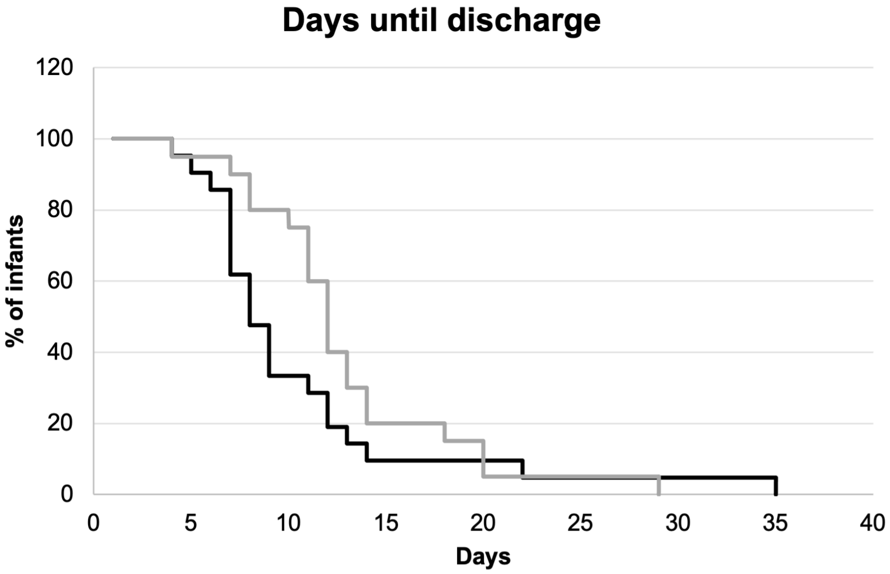

Figure 3. Percentage of infants in the nursery room at a given time point. Infants in the intervention group (black line) were discharged earlier than those in the control group (grey line).

Weight gain

No significant difference was found between groups regarding average weight gain per day (control, 31.35 ± 8.27; intervention, 27.26 ± 7.7; $t = 1.641$, $p = 0.11$) (Fig. 4).

[insert Figure 4.]

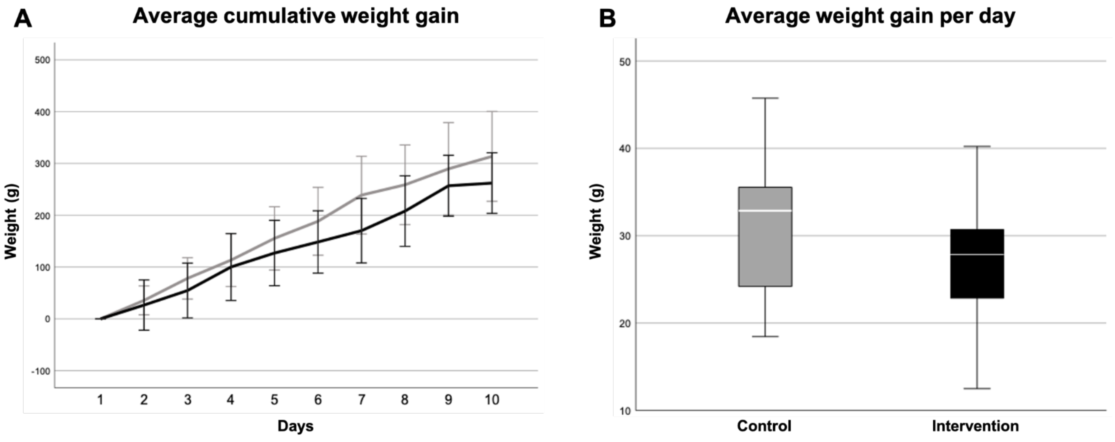

Figure 4. A) Cumulative weight gain of the intervention group (black line) and the control group (grey line) in the first ten days. B) Average weight gain per day during the whole stay in the nursery room.

Of the 41 infants, 34 entered the study before transitioning to oral feeding (control, n = 18; intervention, n = 16). No significant difference was found between the groups regarding number of days until oral feeding (control, 8 [7.5]; intervention, 6 [4.5]; Mann-Whitney U test = 138.5, $p = 0.06$).

Vital signs

Means of heart rate, respiratory rate, SpO2 and body temperature for each group are presented in Figure 5. Statistical differences were found between groups for average heart rate at 14:00 and 20:00 ($t = 2.4$, $p = 0.021$ and $t = 2.4$, $p = 0.02$, respectively). Mean and standard deviation values can be found in Supplementary Table S1.

[insert Figure 5.]

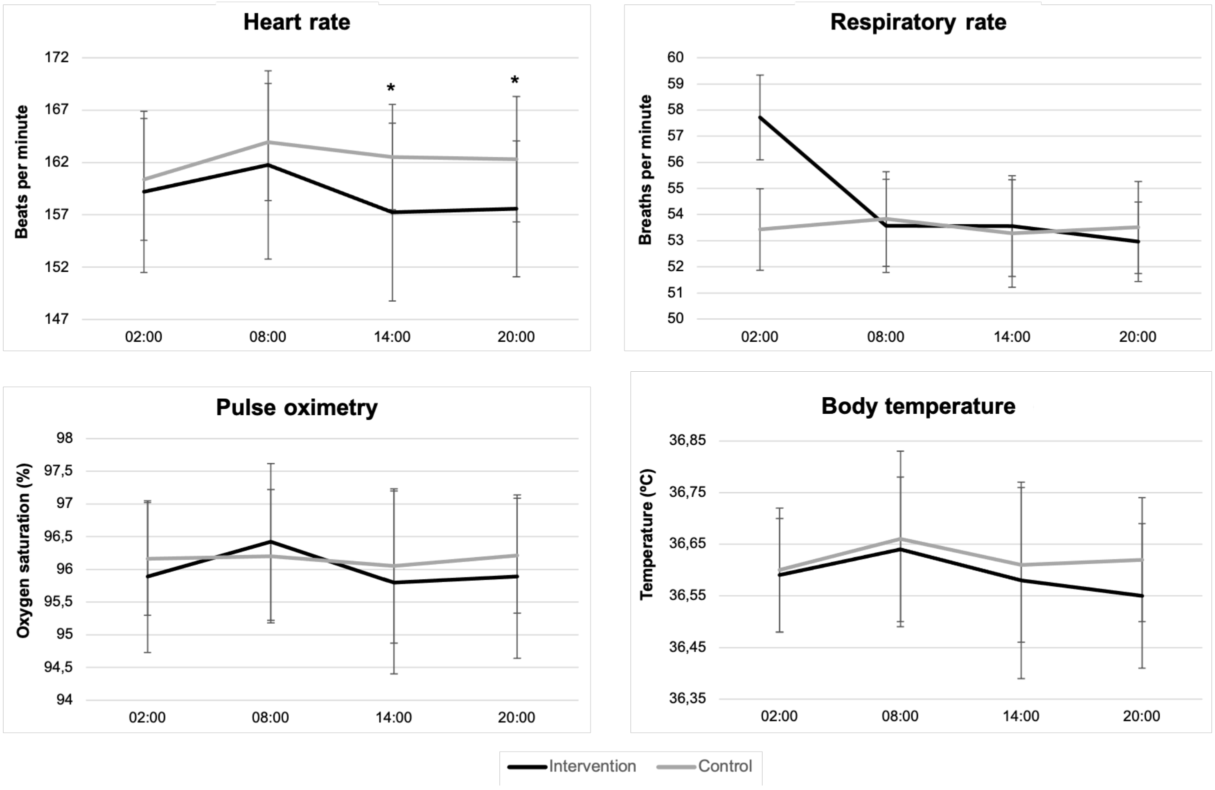

Figure 5. Group means and standard deviations of heart rate, respiratory rate, pulse oximetry and body temperature at four time points. *$p < 0.05$.

The GEE performed for heart rate showed that the interactions time*day and group*time*day were significant ($p = 0.09$ and 0.08, respectively). This indicates that the heart rate difference between groups varies across days and time points. We then compared the estimated marginal means of heart rates at each time point for the first ten days, when the majority of infants were still in the nursery, and found that the heart rate was significantly higher in the control group at 14:00 from day 4 onwards and at 20:00 from day 1 until day 8 (Fig. 6).

[insert Figure 6.]

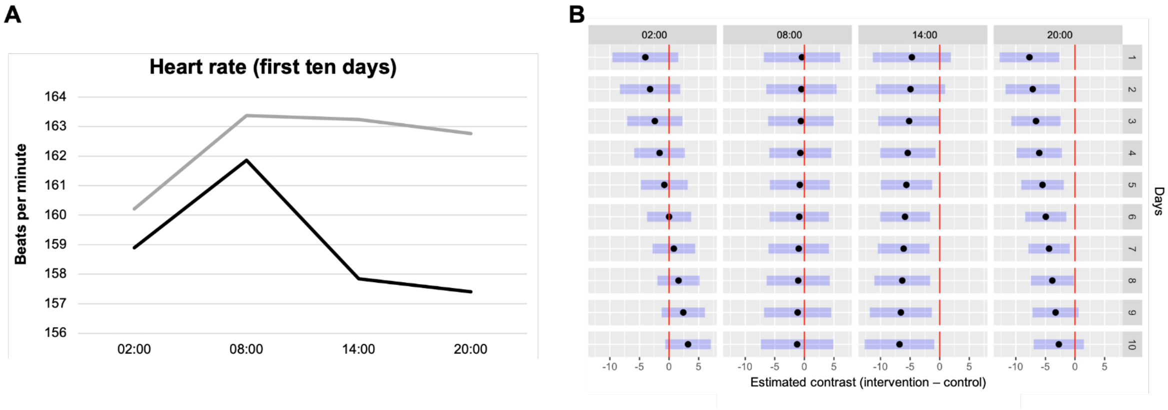

Figure 6. A) Average heart rate of the intervention group (black line) and the control group (grey line) at different time points during the first ten days. B) Multiple comparison of the estimated marginal means at different time points across days. The black dots represent the difference between the estimated marginal means of the two groups, the blue bars represent the standard error and the red lines represent equal values between groups. When a blue bar is not crossing or touching the red line, there is a difference between groups. Negative values indicate that the intervention group had lower estimated marginal means than the control group and positive values indicate that the intervention group had higher estimated marginal means.

DISCUSSION

In the present study, preterm infants wearing individual light protection equipment at night were discharged earlier from the hospital than infants exposed to very low levels of light. We observed no significant differences in weight gain between groups, indicating that the shorter stay was not due to a faster growth. Although the median of days until the beginning of oral feeding was smaller in infants wearing masks at night, no statistically significant difference was found between groups. The intervention group also showed greater heart rate variation throughout the day during several days.

Light is the main environmental clue responsible for entraining human circadian rhythms (Duffy and Wright, 2005). The timing of the exposure, as well as the intensity and wavelength of light that individuals are exposed to, has physiological and behavioral impacts and can be related to either positive or negative health outcomes (Souman et al., 2018; Vethe et al., 2021). In this study, both groups were exposed to near darkness during most of the time, with the difference that infants in the intervention group wore eye masks in order to block the very low levels of ALAN in the room.

In adults, exposure to ALAN is related to negative metabolic outcomes, such as elevated plasma triglycerides and low-density lipoprotein (LDL), decreased high-density lipoprotein (HDL), subclinical atherosclerosis, overweight and obesity (Fleury et al., 2020). Evidence also points to an association between nighttime light exposure and mental health issues, including depression and other mood disorders (Bedrosian and Nelson, 2013). Disruption of circadian rhythms is a potential mechanism behind these effects (Bedrosian and Nelson, 2013). Endogenously-generated circadian rhythmicity is not yet established in preterm newborns and therefore cannot be disrupted, but a study showing the effect of a light-dark cycle on melatonin levels indicate that the introduction of 24h environmental patterns in the NICU (including exposure to dark at night) might promote circadian entrainment (Vásquez-Ruiz et al., 2014). Earlier findings pointed to light intensities of >100 lux at night having deleterious health impacts (Cho et al., 2015), but recent research suggests that exposure to less than 10 lux can reduce melatonin biosynthesis, and even 1 lux can aggravate sleep quality in adults (Cho et al., 2016; Phillips et al., 2019; Stebelova et al., 2020; Tähkämö et al., 2019). Given that melanopsin is present in the eye tissue since early weeks of gestation and that the RHT and the SCN are formed during the second trimester, it is likely that even extreme preterm infants have the ability to sense and respond to light variations (Hazelhoff et al., 2021). To our knowledge, no study has shown the effect of different intensity levels of ALAN on newborns.

Several researchers have investigated the effects of continuous illumination versus cycled lighting patterns in NICUs on the development of preterm infants. The cycled light condition, characterized by light-dark cycles with decreased light exposure at night, has been shown to accelerate weight gain and the beginning of oral feeding (Miller et al., 1995; Vásquez-Ruiz et al., 2014), shorten the stay in the NICU and improve peripheral oxygen saturation and heart rate stability throughout the days (Vásquez-Ruiz et al., 2014), decrease activity, respiratory rate and heart rate during the night (Blackburn and Patteson, 1991; Shiroiwa et al., 1986) and accelerate the emergence of circadian activity-rest rhythms (Rivkees et al., 2004). Cycled light has also been shown to improve weight gain when compared with continuous near darkness (5-10 lux) (Brandon et al., 2002) and to reduce fussing and crying in very preterm infants when compared with dim lighting (97.6 ± 45.3 lux during the day and 20.8 ± 20.7 lux at night) (Guyer et al., 2012). Other studies, however, have found no difference between cycled and continuous dim light conditions (Boo et al., 2002; Mirmiran et al., 2003). In the present study, although not implementing a light-dark cycle, we also observed a decrease in time until discharge in infants wearing light protection devices at night. However, no significant difference was found between groups regarding weight gain and days until the beginning of oral feeding, possibly due to the fact that infants were exposed to a near dark condition during the day.

Factors that can influence the postnatal growth of preterm infants include degree of prematurity, birth weight (appropriate or small for gestational age), nutrition type (breast milk or formula), food intolerance and morbidities (Silveira and Procianoy, 2019. In the present study, no statistically significant difference was found between the two groups regarding degree of prematurity or birth weight. Other factors, however, were not evaluated.

The light-dark pattern is typically achieved through changes in the unit's lighting system and eventually with the use of individual helmets (Vásquez-Ruiz et al., 2014), curtains (Guyer et al., 2012) or incubator coverings (Brandon et al., 2002; Guyer et al., 2012). Although designed to resemble day-night alterations, the cycled condition usually consists of dim light exposure (~25 lux) during the "lights-off" phase (Guyer et al., 2012; Vásquez-Ruiz et al., 2014), since devices such as eye masks, designed to block light as completely as possible, are rarely employed (Shiroiwa et al., 1986). According to the nursing staff, the masks were easy to wear and did not seem to increase restlessness or bother the infants. They are affordable and were already available in the hospital, since typically used for phototherapy. The results presented here, together with findings of studies in adults (Hu et al., 2010), suggest that this low-cost intervention has the potential of bringing health benefits for patients in an intensive care unit.

A methodological limitation of this study is that, since the intervention consists of wearing a mask, the nurses, nurse technicians and neonatologists that also collect daily data are aware of the group division, and therefore a double-blind or single-blind study design was not possible. Besides, because there was no need for 24-hour monitoring of the infants' vital signs, these were only recorded at four time points, which does not allow a precise characterisation of rhythmic patterns. Furthermore, given that the study took place in a nursery where infants with stable vital signs are admitted in order to gain weight, transition to oral feeding and get ready for discharge, the average number of days in the study was lower than if they had been included since birth. This means that possible long-term effects of the intervention could not be assessed. However, the study setting is also one of its strengths. Since the nursery is separated by walls and a corridor from the intensive ward, it provides a more controlled environment for investigating the effect of light variations, with less noise and circulation. In fact, our next step will be the implementation of a dynamic lighting system in the nursery, with color temperature variations that aims to mimic the natural daily ones, in order to investigate the effect of the use of light protection equipment at night coupled with bright light exposure during the day.

Lighting needs in the NICU and other intensive care facilities are different among occupants. Medical interventions or nursing tasks might need to be performed at periods in which the patient would rather stay in the dark. A cycled pattern consisting of bright light during the day and dim light at night is potentially beneficial for both infants and staff (Rea and Figueiro, 2016), and based on our results we believe that coupling a darkened environment at night with individual light protection devices can create the best conditions for the development of preterm infants.

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DECLARATION OF CONFLICTING INTERESTS

The authors declare that there are no conflicts of interests with respect to the research, authorship, and/or publication of this article.

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SUPPLEMENTARY MATERIAL

Table S1 Mean of vital signs at different time points

		Heart rate	**Respiratory rate**	**SpO2**	**Temperature**
02:00	Intervention	159.21 ± 7.7	52.72 ± 1.62	95.89 ± 1.16	36.59 ± 0.11
	Control	160.39 ± 5.82	53.43 ± 1.56	96.16 ± 0.86	36.6 ± 0.12
	p	0.59	0.16	0.41	0.84
08:00	Intervention	161.78 ± 9	53.57 ± 1.78	96.42 ± 1.2	36.64 ± 0.14
	Control	163.96 ± 5.59	53.83 ± 1.81	96.2 ± 1.02	36.66 ± 0.17
	p	0.36	0.65	0.53	0.66
14:00	Intervention	157.26 ± 8.51	53.56 ± 1.93	95.8 ± 1.4	36.58 ± 0.19
	Control	162.53 ± 5.01	53.28 ± 2.06	96.05 ± 1.18	36.61 ± 0.15
	p	< 0.05	0.66	0.54	0.68
20:00	Intervention	157.57 ± 6.49	52.96 ± 1.52	95.89 ± 1.25	36.55 ± 0.14
	Control	162.33 ± 5.99	53.51 ± 1.76	96.21 ± 0.88	36.62 ± 0.12
	p	< 0.05	0.29	0.36	0.1

Data are presented as mean ± SD and compared with Student's *t*-test.
SpO2: oxygen saturation determined by pulse oximetry.

3 CONCLUSÕES E PERSPECTIVAS

Avanços científicos e tecnológicos nas últimas décadas possibilitaram a criação de condições necessárias para o desenvolvimento de neonatos prematuros, mas as taxas de sobrevivência variam drasticamente de acordo com o local de nascimento. Menos de 10% dos prematuros extremos (idade gestacional < 28 semanas) nascidos em países empobrecidos sobrevivem aos primeiros dias de vida, enquanto em países ricos mais de 90% sobrevivem (PLATT, 2014). Fatores sociais e econômicos impactam o desenvolvimento pré- e pós-natal dos bebês, entre os quais se encontram as condições da infraestrutura hospitalar. Profissionais de saúde capacitados e disponibilidade de equipamentos e medicamentos são essenciais para o oferecimento do cuidado necessário, e o espaço físico que constitui o ambiente de internação também pode ter influência nos desfechos de saúde.

Em adultos, a exposição à luz artificial no período da noite acarreta piora na qualidade de sono, redução ou inibição da síntese de melatonina e disrupção dos ritmos circadianos, e está relacionada com prejuízos metabólicos, psiquiátricos e câncer. Um estudo realizado em ambiente de UTI simulado mostrou que o uso de protetor auditivo e máscara para os olhos no período da noite resultou em melhor qualidade de sono, menores níveis de cortisol e maiores níveis de melatonina em adultos. Na UTI neonatal, a exposição a ciclos de claro-escuro foi associada a ganho de peso acelerado, permanência encurtada, início da alimentação oral mais cedo, melhor saturação periférica de oxigênio, frequência cardíaca mais estável ao longo dos dias, aceleração do surgimento dos ritmos circadianos de atividade-repouso e menor atividade e frequências respiratória e cardíaca durante a noite quando comparada a padrões constantes de iluminação (BLACKBURN; PATTESON, 1991; BRANDON; HOLDITCH-DAVIS; BELYEA, 2002; GUYER *et al.*, 2012; MILLER *et al.*, 1995; RIVKEES *et al.*, 2004; SHIROIWA *et al.*, 1986; VÁSQUEZ-RUIZ *et al.*, 2014).

No presente estudo, observamos que neonatos prematuros que utilizaram máscara para proteção contra luz artificial à noite receberam alta mais cedo do que bebês do grupo controle, que estavam expostos a níveis de iluminação muito baixos no mesmo período. Não observamos diferenças significativas no ganho de peso entre os grupos, indicando que o menor tempo de internação não foi devido a uma maior velocidade de crescimento, como originalmente hipotetizado. A mediana de dias até a transição completa de alimentação por sonda para alimentação oral foi menor no grupo intervenção, embora não significativamente; e uma maior variação de frequência cardíaca foi observada no grupo intervenção, com valores menores de batimentos por minuto (bpm) às 14h e às 20h. Não foram detectadas diferenças significativas nas medidas de frequência respiratória, saturação de oxigênio e temperatura corporal entre os grupos nos diferentes horários avaliados.

Em um estudo brasileiro com dados de 2006, o custo diário da internação de um bebê prematuro na UTI neonatal foi estimado entre US$97 e US$157 (MWAMAKAMBA; ZUCCHI, 2014). Outro estudo, mais recente, estimou um custo diário de, em média, US$188 (OGATA *et al.*, 2016). Neste contexto, o uso de máscaras no período da noite é uma intervenção barata que pode reduzir os custos da internação ao diminuir o número de dias até a alta hospitalar, gerando uma economia para o sistema público de saúde, além do potencial que apresentam de trazer benefícios à saúde de pacientes internados em unidade de terapia intensiva.

Como perspectivas, pretendemos continuar a coleta até atingir o número amostral calculado originalmente (N = 68), mas acreditamos que os resultados se manterão similares e que a randomização contribuiu para o controle de possíveis efeitos confundidores. A segunda fase do projeto consistirá na instalação de lâmpadas dinâmicas na UTIN, cuja temperatura de cor varia ao longo do dia, como uma tentativa de mimetizar as transições naturais. O objetivo então será comparar a recuperação de neonatos expostos à luz dinâmica de dia e luzes apagadas de noite com aqueles expostos à luz dinâmica de dia e luzes apagadas com utilização de máscaras de noite.

Uma pergunta que surgiu a partir do presente trabalho é se a exposição a diferentes intensidades luminosas à noite gera efeitos fisiológicos diferentes e proporcionais à quantidade de lux, uma vez que não encontramos estudos na literatura que investiguem isso em neonatos; e se os efeitos variam com relação à quantidade de luz recebida durante o dia. Um possível desenho experimental para responder tal pergunta seria a alocação de neonatos para diferentes combinações de intensidades de iluminação noturna (ex.: 1 lx, 5 lx, 50 lx e 100 lx) e diurna (ex.: 50 lx, 100 lx, 500 lx e 1000 lx), e posterior avaliação de níveis de melatonina e cortisol de manhã e à noite, ritmos de atividade/repouso e sono/vigília, ganho de peso e tempo até a alta.

As necessidades de iluminação na UTI neonatal e em outras unidades de terapia intensiva variam de acordo com os ocupantes do espaço. Para que a equipe de profissionais da saúde possa prover os cuidados adequados, muitas vezes é preciso iluminação forte em horários em que o ideal do ponto de vista fisiológico seria que o paciente estivesse no escuro. Um padrão de iluminação cíclica, com luz intensa durante o dia e fraca durante a noite, tem o potencial de beneficiar tanto neonatos quanto funcionários da unidade e, com base em nossos resultados, acreditamos que unir um ambiente escurecido à noite com dispositivos individuais de proteção contra a luz é uma forma de criar melhores condições para o desenvolvimento de bebês prematuros na UTI.

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APÊNDICE A – FICHA DO PACIENTE

FICHA DO PACIENTE

Número do paciente:___________

1. Idade Gestacional: ____
2. Cidade de nascimento:____
3. Cidade onde mora a família:_______________________________________

Variável	Valor
<34 semanas: New Ballard	
>34 semanas: Capurro	
Peso ao nascer	
Comprimento ao nascer	
Perímetro da cabeça ao nascer	
Resultado teste do pezinho	

Outras informações:

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APÊNDICE B – INSTRUMENTO DE CONTROLE DE SINAIS VITAIS

Estudo: ENSAIO CLÍNICO RANDOMIZADO SOBRE O USO DE EQUIPAMENTO DE PROTEÇÃO CONTRA LUZ ARTIFICIAL NA RECUPERAÇÃO DE NEONATOS PREMATUROS

Controle de Sinais Vitais – SALA DE PREMATUROS

Nome/nº ______________________________ Registro _________________________ Data _____/_____/______

Convênio _______________ Leito ____________ Peso: ________________

HORÁRIOS																			
FC																			
FR																			
VENTILAÇÃO																			
L/IN – CONC. O2																			
SPO2																			
HGT																			
TEMPERATURA																			
RADIÂNCIA																			
DOR																			

HORÁRIOS																			
VOLUME DIETA/VO																			
VOLUME DIETA/SOG-SNG																			
DIURESE																			
EVACUAÇÃO																			
ÊMESE																			
RES. GÁSTRICO																			
COLETAS																			

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- **Original Research**
    - Abstract (300 words)
    - Keywords (at least 5)
- **Letters (about 2,000 words)**

Total word count does not include abstracts, keywords or references.

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>
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