lek. mgr psychologii Kacper Łoś

Mindfulness (uważność), stres oraz funkcje wykonawcze jako cechy wpływające na efekty działania studentów kierunku lekarskiego w symulacjach medycznych

Rozprawa na stopień doktora nauk medycznych

Promotor: prof. dr hab. n. med. Włodzimierz Łuczyński

Zakład Symulacji Medycznych
Klinika Psychiatrii
Wydział Lekarski z Oddziałem Stomatologii i Oddziałem Nauczania w Języku Angielskim

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Dziękuję także mojej rodzinie i narzeczonej, która była i jest dla mnie ogromnym wsparciem w każdej życiowej sytuacji.

Dziękuję mojej Uczelni za możliwość realizacji pracy doktorskiej, za wniesiony wkład w moją edukację oraz za możliwość spotkania na swojej drodze tak wspaniałych mentorów.

Spis treści

Wykaz stosowanych skrótów:

BRI - behavioral regulation index, wskaźnik regulacji zachowań

BRIEF-A - The Behavior Rating Inventory of Executive Functions, Inwentarz Zachowania Funkcji Wykonawczych

CISS - Coping Inventory for Stressful Situations questionnaire, Kwestionariusz Radzenia Sobie w Sytuacjach Stresowych

FFMQ - Five Facet Mindfulness Questionnaire, Pięciowymiarowy Kwestionariusz Uważności

GEC - Global executive composite, Całościowe funkcje wykonawcze

MI - metacognition index, indeks samodzielnego zarządzania

SD - standard deviations, odchylenie standardowe

Wykaz prac wchodzących w skład rozprawy:

Rozprawa doktorska jest przedstawiona jako cykl dwóch spójnych tematycznie prac opublikowanych w recenzowanych czasopismach naukowych, znajdujących się na liście filadelfijskiej:

Praca oryginalna:

Łoś Kacper, Chmielewski Jacek, Łuczyński Włodzimierz. Relationship between executive functions, mindfulness, stress, and performance in pediatric emergency simulations. International Journal of Environmental Research and Public Health: 2020 : 17, 6, 10 pp., Article ID 2040. IF: 3.390, MNiSW: 140.

Praca przeglądowa:

Łoś Kacper, Łuczyński Włodzimierz, Waszkiewicz Napoleon. Can the practice of mindfulness reduce medical errors?
Postępy Psychiatrii i Neurologii: 2022 : 31, 3, 7 pp. MNiSW: 70.

Zestawienie publikacji doktoranta:

Rodzaj publikacji	**Liczba**	**Impact Factor**	**Punktacja MNiSW**
Prace włączone do rozprawy doktorskiej	2	3.390	210
Prace, które nie zostały włączone do rozprawy doktorskiej	7	21.805	695
Streszczenia zjazdowe	1		
Razem	**10**	**25.195**	**905**

Wstęp:

W ciągu ostatnich 10 lat symulacja medyczna wysokiej wierności stała się powszechnym narzędziem edukacji studentów kierunku lekarskiego (1). Zarówno symulacji, jak i realnej pracy lekarza, towarzyszy stres, który może wpływać na jakość opieki nad pacjentem (2). Jedną ze skutecznych metod redukcji stresu jest praktyka mindfulness (uważność, świadoma obecność) (3). Uważność to proces zwracania uwagi na obecną chwilę, na to „co jest we mnie i wokół mnie" bez oceniania, z uwzględnieniem otwartości, ciekawości i akceptacji (4). Cechy mindfulness to postawa akceptacji, braku wartościowania, cierpliwości, nieoczekiwania, miłującej dobroci, troski i współczucia dla bieżącej sytuacji (5). Bycie uważnym (mindful) powoduje, iż odpowiadamy bardziej świadomie a nie automatycznie na sytuacje stresowe (6). Dotychczasowe doniesienia naukowe pokazują, iż cechy uważności mogą mieć związek z jakością opieki nad pacjentem, w tym działaniami lekarskimi w warunkach stresu (3,7).

W pracy lekarza, obok wiedzy medycznej oraz umiejętności praktycznych, stanowiących fundament wykonywania zawodu, coraz bardziej doceniane i przydatne są umiejętności psychospołeczne, zwane kompetencjami miękkimi lub umiejętnościami nietechnicznymi (8). Elementami tych kompetencji są: komunikacja interpersonalna, asertywność, radzenie sobie ze stresem, obrona przed manipulacją, umiejętność negocjacji, rozwiązywanie konfliktów, zarządzanie zespołem i motywowanie pracowników oraz przeciwdziałanie wypaleniu zawodowemu (9). Z drugiej strony, pod uwagę bierze się również funkcje wykonawcze jako zestaw cech, które są odpowiedzialne za zachowania prowadzące do rozwiązywania problemów i realizacji postawionych celów (10).

Ponadto w związku z silnym stresem emocjonalnym, dużą liczbą bodźców odczuwanych głównie w początkowych etapach pracy lekarskiej, poszukuje się metod, które mogłyby ułatwić radzenie sobie z trudnościami (11,12). Praktyka uważności, poprzez redukcję poziomu stresu, poprawia funkcje wykonawcze, pozytywnie wpływa na świadomość sytuacyjną, tym samym może wpływać na zmniejszenie liczby popełnianych błędów przez młodych lekarzy (13).

Cele:

Celem pracy oryginalnej było zbadanie, czy istnieją związki pomiędzy cechami uważności (mindfulness), wpływem stresu i funkcjami wykonawczymi a efektami działań studentów kierunku lekarskiego w czasie symulacji medycznych wysokiej wierności, w stanach zagrożenia zdrowia i życia pacjenta pediatrycznego. Celem pracy przeglądowej była analiza dostępnej, opublikowanej w recenzowanych czasopismach literatury, dotyczącej wpływu mindfulness, stresu, funkcji wykonawczych i świadomości sytuacyjnej na działania młodych lekarzy i ewentualne zmniejszenie liczby popełnianych przez nich błędów medycznych.

Materiał i metody:

Grupa badana

Grupę badaną stanowiło 153 studentów VI roku kierunku lekarskiego Uniwersytetu Medycznego w Białymstoku, odbywających zajęcia w Zakładzie Symulacji Medycznych, w ramach przedmiotu pediatria, którzy wyrazili świadomą zgodę na wzięcie udziału w badaniu. Kryterium wykluczenia była ciąża. Średni wiek badanych wynosił 24,5 ± 2,2. Kobiety stanowiły 63,4 %, mężczyźni 36,6% grupy badanej. Badanie kohortowe przeprowadzono od października 2018 do czerwca 2019 roku.

Metody

W ramach zajęć z pediatrii odbywających się w Zakładzie Symulacji Medycznych, przeprowadzono 306 wystandaryzowanych symulacji wysokiej wierności. Scenariusze dotyczyły stanów zagrożenia życia pacjenta pediatrycznego, były to m.in: częstoskurcz nadkomorowy, drgawki gorączkowe, astma oskrzelowa, kwasica ketonowa, wstrząs anafilaktyczny oraz zatrucie paracetamolem. Podczas symulacji studenci odgrywali różne role: liderów zespołu medycznego, członków personelu medycznego lub opiekunów pacjenta. Każdy ze studentów odgrywał rolę lidera dwukrotnie, za każdym razem w innym, losowo przydzielonym scenariuszu. Prezentowane w rozprawie doktorskiej badania przedstawiają analizę danych dotyczących liderów zespołów medycznych. Przed każdym scenariuszem studenci otrzymali takie same instrukcje i informacje wprowadzające od nauczyciela akademickiego prowadzącego zajęcia. Ponadto, każdy scenariusz posiadał dwa cele: techniczny i nietechniczny, które zostały określone i oceniane w listach kontrolnych przygotowanych i wystandaryzowanych dla każdego ze scenariuszy. Dokładny przebieg

przeprowadzonych w badaniu symulacji jest zawarty w załączonej w przewodzie doktorskim pracy oryginalnej.

W celu oceny związków pomiędzy stanem uważności, stresem, funkcjami wykonawczymi a efektami działań studentów w trakcie symulacji wysokiej wierności zbadano:

1) Cechy uważności z użyciem Pięciowymiarowego Kwestionariusza Uważności (Five Facet Mindfulness Questionnaire, FFQM, wersja skrócona), jest to skala standaryzowana, przetłumaczona na język polski) (14,15).

2) Funkcje wykonawcze z zastosowaniem narzędzia Inwentarz Zachowania Funkcji Wykonawczych (The Behavior Rating Inventory of Executive Functions – Adult, BRIEF-A) (16).

3) Umiejętności nietechniczne z zastosowaniem skali Ottawa (Ottawa Crisis Resource Management Global Rating Scale) (17,18).

4) Umiejętności techniczne (użyto specjalistycznych list kontrolnych zaprojektowanych przez twórców scenariuszy – specjalistów w danej dziedzinie).

5) Somatyczne cechy stresu (częstość pracy serca, ciśnienie tętnicze i subiektywna ocena nasilenia stresu; parametry zostały zbadane dwukrotnie: przed i po zakończonym scenariusza) Oceniony został również styl radzenia sobie ze stresem przy użyciu - Kwestionariusza Radzenia Sobie w Sytuacjach Stresowych - CISS) (19).

Ponadto, przed każdym scenariuszem studenci uzupełnili ankietę dotyczącą dziennego spożycia kawy, przyjmowania leków wypływających na czynność serca oraz praktykowania medytacji/modlitwy.

Analiza statystyczna:

Z użyciem programów Statistica (wersja 13) oraz GraphPrism poszukiwano korelacji pomiędzy cechami uważności, funkcjami wykonawczymi a umiejętnościami technicznymi i miękkimi studentów. Użyto testów U Manna-Whitneya dla zmiennych ilościowych, Chi-kwadrat dla zmiennych jakościowych oraz korelacji rang Spearmana. Dla porównania grup studentów ze względu na styl radzenia sobie ze stresem oraz wcześniejsze praktyki medytacyjne zastosowano testy ANOVA i testy post-hoc (Dunn). $P<0,05$ zostało uznane za istotne statystycznie.

Wyniki:

W przeprowadzonych badaniach kohortowych wzięło udział 153 studentów VI roku kierunku lekarskiego. Kobiety stanowiły 63,4% (n=97), mężczyźni 36,6% (n=56), a średni wiek wynosił 24,5 (SD± 2,2). Z danych ankietowych uzyskano informację, że 62,0% (n=95) wypija 1-3 filiżanki kawy dziennie. Ponadto, 26,8% (n=41) z badanych osób deklaruje regularną medytację/modlitwę, 37,2% (n=57) medytuje/modli się nieregularnie, a 35,9% (n=55) neguje taką praktykę.

Umiejętności techniczne i nietechniczne

Umiejętności techniczne (wywiad, badanie fizykalne, diagnoza, leczenie) zostały ocenione za pomocą specjalistycznych list kontrolnych, zaprojektowanych przez twórców scenariuszy. Badana grupa uzyskała średni wynik 6,8 (SD± 2,0) punktów (maksymalna liczba punktów do uzyskania wynosiła 10). Umiejętności nietechniczne zostały oceniona za pomocą skali Ottawa. Oceniano następujące umiejętności nietechniczne: umiejętności przywódcze, świadomość sytuacyjną, umiejętność komunikacji, rozwiązywanie problemów, wykorzystanie zasobów oraz ogólną skuteczność. Za każdy z wymienionych powyżej elementów student mógł otrzymać od 1 do 7 punktów. Badana grupa otrzymała średnio 28,8 (SD ± 4.8) punktów za oceniane umiejętności nietechniczne. Najwięcej punktów studenci otrzymali za umiejętność: rozwiązywanie problemów (4,9 SD ± 1,0) oraz umiejętność komunikacji (4,9 SD± 1,0). Najmniej uzyskali za świadomość sytuacyjną (4,2 SD ± 1,2). Ponadto analiza statystyczna wykazała dodatnią korelację pomiędzy umiejętnościami technicznymi i nietechnicznymi ($r = 0,7$, $p < 0,0001$). Szczegółowe dane dotyczące wyników umiejętności technicznych i nietechnicznych studentów przedstawiono w tabeli 2 pracy oryginalnej, załączonej w rozprawie doktorskiej.

Stres, style radzenia sobie ze stresem a umiejętności studentów

Przed i po realizacji scenariusza oceniono somatyczne wskaźniki/objawy stresu. Średnia częstość pracy serca przed realizacją scenariusza wynosiła 78,2 uderzeń/min (SD ± 10,3) a po realizacji 82,5 uderzeń/min (SD ± 17,2). Średnie ciśnienie tętnicze krwi przed realizacją scenariusza to 121,3 (SD ± 12,4)/77,1 (SD ± 4,8) mmHg, a po 126,2 (SD ± 11,6)/80,4 (SD ± 4,8) mmHg. Studenci oceniali natężenie stresu przed realizacją scenariusza, w skali od 1 do 10, na 3,8 (SD± 1,9), natomiast po zakończeniu na 4,0 (SD± 2,0). Po wypełnieniu scenariusza, oceniono również subiektywnie odczuwany wpływ stresu na działania podejmowane przez

studentów w trakcie symulacji (1 - zachęcający, 5 – zniechęcający). Średnik wynik podawany przez studentów wyniósł 2,44 (SD ± 0,74).

W trakcie zajęć oceniono również styl radzenia sobie ze stresem badanych studentów przy pomocy kwestionariusza CISS. Najczęstszym okazał się być styl skoncentrowany na zadaniu (40,5%,; n=62), następnie styl emocjonalny (35,2%; n=54), a najrzadszy styl unikający (24,2%; n=27). Szczegółowe dane dotyczące somatycznych wskaźników stresu oraz stylów radzenia sobie ze stresem, ocenianych kwestionariuszem CISS, przedstawiono w tabeli 3 pracy oryginalnej załączonej w rozprawie doktorskiej. Analiza statystyczna nie wykazała różnic między grupami studentów posiadającymi poszczególne style radzenia sobie ze stresem a umiejętnościami technicznymi i nietechnicznymi (ANOVA; p>0,05). Jednakże, osoby ze stylem emocjonalnym oceniały stres przed realizacją scenariusza jako silniejszy, w porównaniu do osób ze stylem skoncentrowanym na zadaniu (4,3 SD ± 1,6 vs. 3,3 SD ± 1,8; $p = 0,01$). Podobnie osoby ze stylem emocjonalnym oceniały retrospektywnie odczuwany stres w trakcie realizacji scenariusza jako bardziej zniechęcający, w porównaniu do osób ze stylem skoncentrowanym na działaniu oraz stylem unikającym (odpowiednio: 2,8 SD ± 0,5; 2,3 SD ± 0,5; 2,3 SD ± 0,4; $p < 0,001$). Analiza statystyczna wykazała ponadto, że studenci którzy oceniali stres jako bardziej zachęcający, otrzymywali więcej punktów za umiejętności techniczne ($r = -0,29$, $p = 0,005$) oraz wykazywali się większą świadomością sytuacyjną, co w praktyce oznaczało częstsze unikanie błędu fiksacji (umiejętność nietechniczna) ($-0,25$, $p < 0,01$). Ponadto studenci, którzy oceniali stres jako mobilizujący, częściej wykazywali się umiejętnością nietechniczną jaką jest wykorzystywanie zasobów, co w praktyce oznaczało poproszenie o pomoc konsultanta, w przypadku napotkania problemów diagnostyczno-terapeutycznych ($r = -0,32$, $p < 0,01$).

Powtarzanie symulacji

Podczas ponownego odgrywania roli lidera, studenci oceniali odczuwany stres jako łagodniejszy, zarówno przed jak i po realizacji scenariusza ($p < 0,001$). Ponadto stres odczuwany podczas symulacji był oceniany retrospektywnie jako bardziej mobilizujący, w porównaniu do odgrywania roli lidera po raz pierwszy ($p < 0,001$). Co więcej, podczas realizacji drugiego scenariusza wzrosła średnia punktacja przyznawana za umiejętności nietechniczne (24,3 SD ± 3,6 vs. 31,9 SD ± 5,1; $p < 0,01$), natomiast nie za umiejętności techniczne (6,4 SD± 2,0 vs. 7,0 ± SD 2,2; $p = 0,1$). Warto podkreślić, że analizując poszczególne umiejętności nietechniczne, istotnej statystycznie różnicy między pierwszym a

drugim scenariuszem nie odnotowano dla świadomości sytuacyjnej (4,0 SD± 1,1 vs. 4,4 ± SD 1,5; $p > 0,1$).

Mindfulness i umiejętności studentów

Cechy mindfullness zostały ocenione za pomocą skali FFMQ, w której to studenci uzyskali średni całościowy wynik 3,24 (SD ± 0,4). Należy podkreślić, że średni wynik w skali FFMQ przedstawionej grupy badanej nie różnił się od średniego wyniku uzyskanego przez grupę Polaków w podobnym wieku (15). W użytej skali najwięcej punktów badana grupa uzyskała za cechę „opisywanie" (3,56 ± 0,6), a najmniej za cechę „niereagowanie" (2,92 ± 0,7). Całościowa punktacja w skali FFMQ nie była związana z umiejętnościami technicznymi i nietechnicznymi studentów. Wykazano jednak, że jedna z cech mindfulness: „nieocenianie", jest dodatnio skorelowana z całościową punktacją uzyskaną za umiejętności techniczne ($r = 0,27$, $p < 0,01$). Dodatkowo, cecha mindfulness: „świadome działanie" pozostawała w dodatniej korelacji z poszczególnymi umiejętnościami nietechnicznymi odpowiednio z: świadomością sytuacyjną ($r = 0,28$, $p = 0,001$) i wykorzystywaniem zasobów ($r = 0,26$, $p < 0,01$). Szczegółowe dane dotyczące wyników w skali FFMQ znajdują się w tabeli 1 pracy oryginalnej załączonej w rozprawie doktorskiej.

Funkcje wykonawcze

Funkcje wykonawcze zostały ocenione za pomocą: Inwentarza Zachowania Funkcji Wykonawczych (BRIEF-A). Mniejsza liczba otrzymanych w inwentarzu punktów oznaczała lepiej rozwinięte funkcje wykonawcze. Analiza statystyczna wykazała negatywną korelację między funkcjami wykonawczymi a umiejętnościami nietechnicznymi osiąganymi przez studentów. Ponadto wszystkie funkcje wykonawcze były również negatywnie skorelowane ze składnikami uważności w skali FFMQ : BRI ($r = -0,49$, $p < 0,0001$), MI ($r = -0,28$, $p < 0,001$) i GEC ($r = -0,44$, $p < 0,0001$). Szczegółowa dane dotyczące wyników w skali BRIEF-A znajdują się w tabeli 1 pracy oryginalnej załączonej w rozprawie doktorskiej.

Wnioski:

Uzyskane wyniki wskazują, iż cechy mindfulness, funkcje wykonawcze oraz stres wpływają na umiejętności studentów w trakcie sytuacji zagrażających życiu i zdrowiu dziecka. Konieczne są dalsze, randomizowane badania pokazujące czy poprawa uważności czy funkcji wykonawczych wpłynie na zwiększoną efektywność działań zespołów medycznych.

Mindfulness (uważność), stres oraz funkcje wykonawcze jako cechy wpływające na efekty działania studentów kierunku lekarskiego w symulacjach medycznych – streszczenie

Wstęp:

W ostatnich latach symulacja medyczna wysokiej wierności stała się skuteczną, szeroko akceptowaną i popularną metodą edukacji medycznej. W trakcie takich zajęć w Centrach Symulacji Medycznej naucza się nie tylko aspektów technicznych, ale również umiejętności współpracy w zespołach medycznych. Dzięki zachowaniu wysokiej wierności, studenci w bezpiecznych, kontrolowanych warunkach, mogą być nauczani prawidłowego postępowania z pacjentem w stanie zagrożenia życia, jednak narażeni są również na silny stres, podobny do sytuacji w realnych warunkach oddziałów ratunkowych. Negatywny wpływ stresu zarówno w symulacji, jak i w pracy z rzeczywistym pacjentem może oddziaływać na funkcje wykonawcze zespołów medycznych: między innymi na uwagę i pamięć uczestników.

Praktyka mindfulness (uważności) jest jedną ze skutecznych metod radzenia sobie ze stresem. Mindfulness to proces zwracania uwagi na obecną chwilę, bez oceniania, z uwzględnieniem otwartości, ciekawości i akceptacji. Możliwe, iż stres, uważność, funkcje wykonawcze oraz ich wzajemne zależności wpływają na jakość działań zespołów medycznych.

Celem pracy było zbadanie czy mindfulness, stres oraz funkcje wykonawcze są związane z umiejętnościami technicznymi i nietechnicznymi studentów medycyny w czasie symulacji medycznych w pediatrii.

Uczestnicy i metody:

Do badania zakwalifikowano 153 studentów ostatniego roku kierunku lekarskiego. Przeprowadzono łącznie 306 symulacji wysokiej wierności o tematyce zagrożeń życia dziecka. Oceniano stres, funkcje wykonawcze, mindfulness oraz umiejętności techniczne i nie-techniczne uczestników symulacji pełniących rolę kierowników zespołów.

Wyniki:

1. Stres i sposób radzenia sobie z nim wpływały na umiejętności studentów w trakcie symulacji pediatrycznych.
2. Powtarzanie różnych scenariuszy w tym samym zespole poprawiało istotnie umiejętności nietechniczne, ale nie proceduralne studentów.

3. Niektóre składowe mindfulness takie jak nieosądzanie oraz świadome działanie były pozytywnie związane z umiejętnościami kierowników zespołów medycznych.
4. Funkcje wykonawcze korelowały z umiejętnościami nietechnicznymi oraz uważnością studentów kierunku lekarskiego.

Wnioski:

Stres, mindfulness oraz funkcje wykonawcze modelują zachowania i umiejętności studentów medycyny w trakcie symulacji zagrożenia życia dziecka. Dalsze badania w tym zakresie mogą udowodnić czy trening mindfulness będzie prowadził do uzyskania lepszych efektów w nauczaniu medycyny ratunkowej dzieci.

Mindfulness (awareness), stress, and executive functions as attributes affecting medical students' performance in medical simulations – abstract

Background:

In recent years, high-fidelity medical simulation, has become an effective, widely accepted and popular method of medical education. During such classes at Medical Simulation Centres, not only technical procedural skills are taught, but also teamwork (non-technical skills, team training). By providing high fidelity, students can be taught the proper management of a patient in a life-threatening condition under safe, controlled conditions, but they are also exposed to severe stress, similar to real-life emergency department situations. The negative impact of stress in both: simulation and real patient care, affects the executive functions of medical teams participants: attention and memory.

Mindfulness practice is one of the effective methods of coping with stress. Mindfulness is the process of intentionally paying attention to the present moment without judgment, including openness, curiosity and acceptance. It is possible that stress, mindfulness, executive functions and their interrelationships affect the quality of medical teams' performance.

The aim of this study was to examine whether mindfulness, stress and executive functions are related to the technical and non-technical skills of medical students participating in medical simulations in pediatrics.

Participants and methods:

The study included 153 final-year medical faculty students. A total of 306 high-fidelity simulations of life-threatening situations involving children were conducted. The stress, executive functions, mindfulness, and technical and non-technical skills of the participants acting as team leaders were assessed.

Results:

1. Stress and the coping mechanism of the participants affected their skills during pediatric simulations.
2. Repeating various scenarios in the same team significantly improved the students' non-technical skills but not procedural ones.
3. Some components of mindfulness, such as non-judgment and conscious action, were positively related to the skills of medical team leaders.

4. Executive functions correlated with the non-technical skills and mindfulness of the medical students.

Conclusions:

Stress, mindfulness, and executive functions model the behavior and skills of medical students during pediatric simulations of life-threatening events. Further research in this area may prove whether mindfulness training will improve learning outcomes in pediatric emergency medicine.

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Relationship between Executive Functions, Mindfulness, Stress, and Performance in Pediatric Emergency Simulations

Kacper Łoś, Jacek Chmielewski and Włodzimierz Łuczyński *

Department of Medical Simulations, Medical University of Białystok, 15-274 Białystok, Poland; kacperlos13@gmail.com (K.Ł.); mbrppolska@gmail.com (J.C.)

* Correspondence: w.luczynski@wp.pl

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Abstract: Over the past decade, high-fidelity medical simulation has become an accepted and widely used teaching method in pediatrics. Both simulation and work in the real conditions of emergency departments are accompanied by stress that affects the executive functions of participants. One of the methods for reducing stress among medical students and healthcare professionals is the practice of mindfulness. The aim of this study was to examine whether executive functions, mindfulness, and stress are related to the technical and non-technical skills of medical students participating in medical simulations in pediatrics. The study included 153 final-year medical students. A total of 306 high-fidelity simulations of life-threatening situations involving children were conducted. Results: Stress and the coping mechanism of the participants were correlated to their skills during pediatric simulations. Some components of mindfulness, such as non-judgment and conscious action, were positively related to the skills of medical team leaders. Executive functions correlated with the non-technical skills and mindfulness of the medical students. Conclusions: Stress, mindfulness, and executive functions modeled the behavior and skills of medical students during pediatric simulations of life-threatening events. Further research in this area may prove whether mindfulness training will improve learning outcomes in pediatric emergency medicine.

Keywords: medical simulation; medical education; mindfulness; executive functions; pediatric emergency; stress

1. Introduction

Pediatric emergency medicine is a demanding field for young doctors and one in which knowledge, experience, and skills are essential. Both procedural and non-technical skills are important. Non-technical skills are also known as teamwork skills and include leadership, teamwork, situational awareness (SA; avoiding fixation error), decision-making, resource management, safe practice, adverse event minimization, and professionalism [1]. Effective and safe teaching methods for these skills are sought, and one of them may be a high-fidelity medical simulation. Over the past decade, simulation has become an accepted and widely used

teaching method in pediatrics [2]. Child resuscitation, trauma management, procedural skills, and teamwork (non-technical skills) can be taught safely using this technique [3]. Due to its repeatability and the standardization of assessment methods, a high-fidelity pediatric simulation is also a good tool for scientific research. In particular, simulations can be useful to evaluate the personal characteristics that affect the behavior of the people involved [4].

Both simulation and work in the real-life conditions of emergency departments are accompanied by stress that affects the executive functions (EFs) of the participants, including attention and memory. Attention lapses increase the risk of serious consequences, such as medical errors, failure to recognize

life-threatening signs and symptoms, and other essential patient safety issues [5]. Learning through simulation could improve stress management in critical situations. Mindfulness is one of the methods used by healthcare professionals for stress reduction. Mindfulness is the process of intentionally paying attention to each moment with curiosity, openness, and acceptance without judgment [6]. The goal of mindfulness is to empower individuals to respond to situations consciously, rather than automatically. Among medical students, being mindful is associated with decreased stress, anxiety, and depression and with improved mood, self-empathy, and empathy [7]. Therefore, dispositional mindfulness may increase opportunities for young doctors to engage in error detection or correction involving emotional/behavioral regulation and cognitive control because they are more aware of cognition when self-regulatory behavior is needed.

The executive functions may influence the behavior of medical team leaders. The EFs are a collection of processes that are responsible for guiding, directing, and managing cognitive, emotional, and behavioral functions, particularly during novel problem-solving [8]. Specific subdomains that make up this collection of regulatory or management functions include the ability to initiate a behavior, inhibit the competing actions or stimuli, select relevant task goals, plan and organize a means to solve complex problems, shift problem-solving strategies flexibly when necessary, and monitor and evaluate behavior. Impairment of the EFs may cause several challenges, like difficulties dealing with novel situations and forming a reasonable plan that considers the relevant details, the inhibition of inappropriate responses to situations, and increased distractibility [9]. A small group of studies has revealed that higher mindfulness is associated with better executive functioning [10].

It is possible that stress, mindfulness, and EFs, and their interrelationships are important players in emergency cases in pediatrics. There is no research published on the subject in the available literature. For this reason, we conducted standardized, repeated high-fidelity pediatric simulations among final-year medical students to assess their mindfulness, EFs, and technical and non-technical skills as leaders of medical teams. We hypothesized that mindfulness, EF, and stress are related to the skills of medical students during simulation activities. Our results might allow us to design strategies to enhance the skills of young doctors to improve the performance of pediatric emergency medicine teams in the future.

2. Participants and Methods

2.1. Participants

The project was an observational cohort study in a group of final-year medical students (ClinicalTrials.gov ID: NCT03761355). The research was conducted between October 2018 and June 2019 in the Department of Medical Simulations at the Medical University of

Białystok, Poland. The inclusion criterion was being a student of medicine and giving consent to participate in the study. The exclusion criterion was pregnancy.

2.2. High-fidelity Pediatric Simulations

The simulations were constructed as high-fidelity scenarios of life-threatening situations involving children. The topics included were supraventricular tachycardia, febrile convulsions, bronchial asthma, ketoacidosis, anaphylactic shock, and paracetamol intoxication. The simulations started in the morning and were identical for all groups of students. All groups received the same introduction to the simulator and medical equipment based on checklists and experienced the scenarios in the same order. The task difficulty was intermediate and was evaluated based on the pilot simulations with both students and residents. Each scenario had two equal goals—technical and non-technical. During the simulation, the students played different roles: team manager, medical team member, or actor—the patient's caregiver. The analysis concerned only the scenarios in which the students acted as team leaders and included an assessment of their skills and interactions with the other participants.

The following data were collected: age, sex, participation in mindfulness training or other secular or religious meditations, medicines taken, and amount of caffeine consumed before the simulation. The number of high-fidelity simulations the students were part of on a given day and during their entire medical studies was also noted.

Stress and its impact on simulation were assessed both subjectively by the participants (the higher the score, the greater or more discouraging the stress) and by measuring the heart rate and blood pressure before and after the simulation. The stress-coping style of the team leader was diagnosed with the Polish adaptation of the Coping Inventory for Stressful Situations (CISS) questionnaire [11]. The CISS questionnaire consists of 48 statements about different behaviors that are typical for people in distress. Participants have to determine the frequency, on a five-point scale, of a given behavior in stressful, difficult situations. The scores are formatted on three scales: task-oriented style, emotion-oriented style, and avoidant style.

2.3. Procedural and Non-technical Skills

Technical skills were assessed based on checklists designed for each scenario. The assessment was divided into an interview, a physical examination, diagnosis, and treatment. The more points on the scale, the better the technical skills.

Non-technical skills were assessed using the Ottawa Crisis Resource Management Global Rating Scale (Ottawa GRS) and checklist [12,13]. This tool has well-defined rating scales for each of its categories: leadership skills, situational awareness, communication skills, problem-solving, and resource utilization [12]. Each category is measured on a seven-point anchored ordinal scale with descriptive anchors to provide guidelines on alternating points along the scale. For example, for the indirect assessment of situational awareness from "becomes fixated easily despite repeated cues; fails to reassess and re-evaluate situation despite repeated cues; fails to anticipate likely events" = 1 point, to "avoids any fixation error without cues; constantly reassesses and re-evaluates situation without cues; constantly anticipates likely events" = 7 points. The higher the Ottawa GRS score, the better the non-technical skills. Non-technical skills were assessed by two independent instructors/observers during each simulation. Mean scores between the two observers were used as the reference value.

2.4. Mindfulness

Mindfulness was assessed according to the short version of the Five Facet Mindfulness Questionnaire (FFMQ), after Polish adaptation and validation [14,15]. The FFMQ is used to measure the depth of mindfulness, and it evaluates five factors: conscious presence, non-

reactivity, non-judgment, observation, and description. The higher the FFMQ score, the higher the level of mindfulness.

2.5. Executive Functions

The cognitive functions were assessed with the Behavior Rating Inventory of Executive Functions—Adult (BRIEF-A). It is a 75-item standardized self-report questionnaire constructed with ecological validity in mind to measure executive functioning in daily life situations [16,17]. The results are summarized as a behavioral regulation index (BRI = inhibit, shift, emotional control, monitor, initiate), metacognition index (MI = working memory, plan to organize, organization of materials, task monitor), and global executive composite (GEC = BRI + MI). Lower scores indicate better executive functioning. Values ≥65 are considered abnormally elevated [18].

Data were presented as means and standard deviations (SD) and rates of incidence of a given characteristic in the group of students. Univariate analysis was conducted using the Mann–Whitney U test for continuous variables, and the Chi-square test for the nominal ones. Correlations were performed using Spearman's rank correlation coefficient. To find the differences between the groups of students with regard to stress-coping style or previous meditation practice, ANOVA and posthoc pair-wise comparisons were performed. $p < 0.05$ was considered statistically significant. Statistical analysis was performed using the Statistica 13 software (StatSoft, Tulsa, Oklahoma, OK, USA). Only students with all data available were included in the analysis.

The study design was approved by the Ethics Committee at the Medical University of Bialystok in accordance with the Declaration of Helsinki (No R-I-002/358/2017). Signed informed consent was obtained from the students. The rate of consent was 85.9%. The main reason for consent refusal was the lack of time to complete the survey. Students who agreed to participate in the study and those who did not give their consent did not differ in sex, age, or in technical and non-technical skill assessment scores.

3. Results

The study included 153 medical students, and each of them played the role of team leader twice. Therefore, a total of 306 simulations were carried out. A summary of data on age, sex, caffeine and drug use, previous meditation practices, and results in mindfulness and student EF scales are provided in Table 1.

Table 1. Data on students participating in medical simulations.

Age (years: mean ± SD)	24.5 ± 2.2
Sex (N/%)	
Male	56/36.6%
Female	97/63.4%
Caffeine consumed before simulations (N/%) no	
	58/37.9%
1–3 cups a day	95/62.0%
>3 cups a day	12/7.8%
Taking medicines affecting heart rate (N/%):	
yes	4/2.6%
no	149/97.4%
Meditation/praying (N/%):	
does not practice	55/35.9%

irregularly	57/37.2%
regularly	41/26.8%
Mindfulness in FFMQ scale (mean ± SD) conscious presence	3.29 ± 0.5
non-reactivity	2.92 ± 0.7
non-judgment	3.00 ± 0.7
observation	3.42 ± 0.8
description	3.56 ± 0.6
total score in FFQM scale	3.24 ± 0.4
Executive functions in BRIEF-A scale (mean ± SD) behavior regulation index (BRI)	63.6 ± 10.8
metacognition index (MI)	60.1 ± 10.0
global executive composite (GEC = BRI + MI)	62.5 ± 9.4
clinically significant decrease in EFs (number and %)	34/22.2%

EFs: executive functions; SD: standard deviation; FFMQ: Five Facet Mindfulness Questionnaire; BRIEF- A: Behavior Rating Inventory of Executive Functions—Adult.

Praying or previous meditation practice was not correlated with the values obtained on the mindfulness scale (analysis of variance analysis (ANOVA)). The average mindfulness score on the FFQM scale did not differ from that of the reference in the group of young adult Poles [14]. It was also not different from the score obtained in the previous year with a different group of students (data not published).

3.1. Technical and Non-Technical Skills

The average scores for all students in technical and non-technical skills are presented in Table 2. The average score for situational awareness (SA, i.e., avoidance of fixation error) was statistically lower compared to other non-technical skills. A strong positive relationship was noted between procedural and non-technical skills ($r = 0.7$, $p < 0.0001$).

Table 2. Student results in terms of technical and non-technical skills.

Technical Skills (total) *	**Mean ± SD**
	6.8 ± 2.0
Non-technical skills (total) **	28.8 ± 4.8
overall performance	4.7 ± 1.1
leadership skills	4.8 ± 1.1
Problem-solving skills	4.9 ± 1.0
situational awareness skills ***	4.2 ± 1.2
resource utilization skills	4.9 ± 0.9
communication skills	4.9 ± 0.8

* maximum 10 points; ** maximum 42 points; *** mean results for all students were statistically significantly lower than other non-technical skills ($p < 0.001$). SD: standard deviation.

3.2. Stress, Stress-coping Style, and Students' Skills

The stress-coping style, heart rate, arterial pressure, and subjective assessment of stress related to the simulation are presented in Table 3. We did not note differences in the students' skills relative to their stress-coping style (ANOVA, $p > 0.05$). In contrast, stress before a simulation was more severe in students with an emotion-oriented stress-coping strategy than in those with a task-oriented strategy (4.3 ± 1.6 vs. 3.3 ± 1.8; $p = 0.01$). Similarly, stress was more discouraging among students with an emotion-oriented coping style than in those with task-oriented and avoidant styles (2.8 ± 0.5, 2.3 ± 0.5, and 2.3 ± 0.4, respectively; $p < 0.001$).

Table 3. Stress-coping style and its perception by students before and after simulations.

Stress-coping style:	N/%
task-oriented style	62/40.5%
avoidant style	37/24.2%
emotion-oriented style	54/35.2%
	Mean ± SD
Mean subjective perception of stress before and after simulation (1—no stress, 10—very stressed)	3.8 ± 1.9 vs. 4.0 ± 2.0 (p > 0.05)
Heart rate before and after the scenario	78.2 ± 10.3 vs. 82.5 ± 17.2 (p > 0.05)
Blood pressure before and after the scenario (systolic/diastolic)	121.3 ± 12.4/77.1 ± 4.8 mmHg vs. 126.2 ± 11.6/80.4 ± 4.8 mmHg (p > 0.05)
Subjective assessment of the influence of stress on the performance during simulation (1—mobilizing, 5—discouraging)	2.44 ± 0.74

We observed correlations between stress, the role played during the simulation, and the students' skills. The more mobilizing was the stress perceived by the students, the higher their technical skill score (r = −0.29, $p = 0.005$), and the better their SA (the more often they avoided the fixation error; r = −0.25, $p < 0.01$). If the students played the role of team leader, the stress after the simulation was greater than when they were team members (r = −0.3, $p < 0.01$). The smaller the students' relative stress during the simulation, the more often they asked for help from a consultant when it was needed (resource utilization skills; r = −0.32, $p < 0.01$). Considering the participants' previous experience in high-fidelity simulations, the more scenarios a student completed before the start of the study, the more stress felt before performing the task (r = 0.25, $p = 0.005$), and the stress was more discouraging (r = 0.28, $p < 0.01$).

3.3. Repeating Simulations in the Same Team

When the same student acted as a team leader in repeated simulations (different scenarios, but with the same level of difficulty), there was a decrease in the perceived stress before and after the next simulation ($p < 0.001$). Furthermore, stress was perceived as more mobilizing in the subsequent simulation ($p < 0.001$).

Regarding the performance in subsequent simulations, the students' non-technical skills improved (24.3 ± 3.6 vs. 31.9 ± 5.1; $p < 0.01$) but not their procedural skills (6.4 ± 2.0 vs. 7.0 ± 2.2; $p = 0.1$). Similar results were obtained by analyzing the subscales of non-technical skills. The exception was SA, for which the difference was not statistically significant (4.0 ± 1.1 vs. 4.4 ± 1.5; $p > 0.1$).

3.4. Mindfulness Components are Related to Students' Skills During Simulation

The total score on the FFQM scale was not related to any of the student skills. In contrast, non-judgment (one of the components of mindfulness) was positively associated with the total score of technical skills (r = 0.27, $p < 0.01$). In addition, more conscious action was associated with better SA and the use of available forces and resources among non-technical skills (r = 0.28, $p = 0.001$ and r = 0.26, $p < 0.01$, respectively).

3.5. Executive Functions and Students' Skills and Mindfulness

EFs positively correlated with the students' non-technical actions. The total EF result, i.e., total GEC, was associated with problem-solving skills (r = −0.26, $p < 0.001$). The EFs "plan organize" and
"task-monitor" were associated with all non-technical skills (total: r = 0.32, $p < 0.001$), including the strongest association with general impression (r = −0.33, $p = 0.001$), team management (r = −0.30, $p = 0.001$), and team communication (r =−0.29, $p = 0.001$). The EF "organization of materials" correlated with the ability to communicate with the team (r = −0.28, $p < 0.01$), and the summary of the MI correlated with the use of names and closed-loop (r = −0.26, $p = 0.01$).
All EFs of the BRIEF-A tool were also positively correlated with FFMQ mindfulness: BRI (r = −0.49, $p < 0.0001$), MI (r = ¯0.28, $p < 0.001$), and GEC (r = ¯0.44, $p < 0.0001$).

4. Discussion

Using repeated high-fidelity pediatric simulations, we showed a relationship between features, such as stress, mindfulness, and EFs, and the skills of final-year medical students. These results could be useful in improving the learning outcomes of students and young doctors in the field of pediatric emergency medicine.
We noticed a strong correlation between the technical and non-technical skills of students. A similar relationship has been demonstrated among French Emergency Medical Service workers during simulations at both the individual and team levels [19]. In addition, the performance of simulation participants was positively associated with their self-confidence and negatively associated with their dissatisfaction. Among our students, the perception of stress as mobilizing also correlated with a better result in the assessment of technical skills. Moreover, lower stress correlated with a more frequent request for help from a consultant in situations when it was necessary to complete the task. A novelty in our research was the repetition of simulations in similar conditions, with the same team leader but different tasks. As a result, we observed a decrease in the feeling of stress and stress perceived as more mobilizing by the participants. Similar positive results were obtained in nurses: repeating simulations with the same team reduced stress and anxiety and increased self-confidence in life-threatening situations [20]. However, one should remember that when dealing with, seriously, a child, there will always be a difference in stress between simulated and real cases. The latter will be characterized by a higher emotional impact ("being a parent" vs. "not being a parent"), which can influence both technical and non-technical skills. Either way, simulation instructors should design their scenarios so that their participants learn to control stress and use it for effective learning and action in real cases.
In our research, we observed lower student performance in terms of situational awareness compared to other non-technical skills. SA was associated with the students' perception of stress as a mobilizing and conscious component of mindfulness. In contrast to other non-technical skills, SA did not improve in subsequent scenarios. SA, next to communication and leadership, is essential when managing a team in a life-threatening situation [21]. Loss of SA

can lead to errors. Occasionally, even though team members may notice something and are able to make a correct diagnosis or suggest proper treatment, they do not speak up. The reasons for this include not wanting to be wrong, not wanting to hurt someone's feelings, or not being sure [22]. Simulations seem to be a great tool to learn and improve this critical skill in emergency medicine departments [23]. In our scenarios, SA was assessed indirectly by teachers observing the scenario. A direct assessment of this skill could be done with the situation global assessment technique (SAGAT) scale. However, this tool is difficult to use because it requires stopping the simulations several times. In our study, we observed a relationship between SA and the students' technical skills, including achieving the goals of the scenario. In contrast to our results, similar pediatric simulations have shown no relationship between SA as assessed by the SAGAT method and achievement of the goal of the scenario [24]. In another study, this skill correlated with the team's clinical performance but did not correlate with the team's perception of shared understanding, team leader effectiveness, or team experience—similar to our results [25]. There are tools to improve SA. For instance, the simulation-based crisis resource management training implemented among pediatric cardiac intensive care unit providers has improved the reporting of doubts about the appropriate procedure to the team leader [26].

Another method for improving SA may be mindfulness, which plays an important role in the performance of medical teams in the stressful conditions of emergency medicine. In our observations, the total mindfulness score was not related to student skill results. However, non-judgment positively correlated with the total score of technical skills and conscious presence. Certainly, the characteristics of mindfulness and self-compassion in pediatric residents are associated with less stress and greater confidence in compassionate childcare [27]. Among residents working in the intensive care unit, mindfulness is also associated with their performance and communication [28]. On the other hand, it has been observed that lower mindfulness scores among volunteers working as psychosocial emergency care personnel may be related to their primary traumatization (post-traumatic stress disorder, PTSD) [29].

Improving mindfulness is worth considering since it is a modifiable characteristic and can lead to better patient care. It seems that the implementation of mindfulness training in emergency medicine departments is feasible and sustainable [30]. After completing mindfulness courses, residents have admitted increased awareness, self-reflection, self-acceptance at work, and acceptance of their own limitations [31]. Moreover, they have mentioned being more resilient and better at setting priorities and limits. In addition, the residents have asked for help more often and seemed to be more open to feedback. They have also indicated an enhanced sense of compassion for others. In an interesting study, mindfulness meditation training led not only to a change in the perception of stress but also to improvement in technical skills (epinephrine administration, defibrillation) and in teamwork during cardiopulmonary arrest simulation [32].

We noted a strong relationship between EFs and the students' skills during teamwork. Better performance in EFs was associated with better scores in non-technical skills. To date, no such studies have been conducted, and the literature on the relationship between EFs and medical actions is scarce. From our observations, it should be concluded that EFs correlates with the effectiveness of student teams during pediatric life-threatening situations. It is also known that stress in medical students causes temporary impairment of EFs [33]. However, the evaluation of the EFs of our students was carried out before the simulations. Mindfulness training partially prevents the functional impairment associated with high-stress contexts, such as in a military cohort [34]. Executive impairment is also associated with the risk of professional burnout syndrome among healthcare professionals [35].

In our study, mindfulness features correlated with the EFs of medical students. Mindfulness meditation certainly affects the EFs, but the impact appears to be more specific than general. After mindfulness training, the greatest improvement in EFs is observed in inhibition, while the impact on the updating and shifting domains is variable (reviewed in [36]). Recently, a pilot

study showed an improvement in well-being and EFs, including working memory in surgery residents, after an 8-week mindfulness course [37]. The combination of mindfulness meditation and cognitive training can lead to an improvement in decision-making competence [38]. It is possible that characteristics, such as awareness of the inhibitors and facilitators of rationality, development of comprehensive awareness of cognitive and affective biases and how to mitigate them, and engagement of metacognitive processes, such as reflection and mindfulness, will lead to improved effectiveness of medical teams [39]. In the future, medical universities should include mindfulness as part of their medical student training so as to improve the skills of students and young doctors during stressful situations.

The strengths of our study were a large number of participants, the repetition of the simulations, the use of checklists to assess the students' skills, the use of standardized mindfulness assessment methods, and the unique pediatric simulation scenarios. However, the results of our research should be interpreted with caution. Our study had several limitations: a lack of assessment of the impact of leader behavior on the work of team members; conduction of the study in a simulation center, with its unique procedures and resources; and the indirect assessment of soft skills, including SA. Our results indicated relationships between stress, mindfulness, EFs, and student performance during pediatric simulations. In the future, a standardized, randomized intervention should be performed on a similar group of students to assess the impact of mindfulness training on their EFs and skills during stressful situations when the life of a child is at risk.

5. Conclusions

The results of our study indicated that EFs, mindfulness, and stress were related to the skills of medical students during simulations of life-threatening situations involving children. Further randomized studies are needed to examine whether an improvement in mindfulness or EFs increases the effectiveness of team action in emergency medicine.

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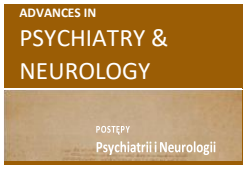
REVIEW ARTICLE



Correspondence to:

Kacper Łoś
Department of Psychiatry
Medical University of Bialystok 2 Wołodyjowskiego St. 15-272 Białystok, Poland e-mail: kacperlos13@gmail.com

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Can the practice of mindfulness reduce medical errors?

Kacper Łoś[1] , Włodzimierz Łuczyński[2], Napoleon Waszkiewicz [1]

[1]Department of Psychiatry, Medical University of Bialystok, Poland
[2]Department of Medical Simulations, Medical University of Bialystok, Poland

Abstract

Purpose: In this article we consider the impact of mindfulness as an effective method of coping with stress and review the available literature on this topic; in addition, we share our 5 years of experience working with final year medical students.

Views: Working in a hospital is a demanding and stressful job. Despite the rapid development of new technologies, the number of medical errors is not decreasing. In this paper we look for effective methods to improve medical education with a focus on the effects of stress on situational awareness (SA) and executive functions (EF). This study provides information on the beneficial effects of mindfulness techniques that, by influencing EF and SA, can directly reduce physicians' errors.

Conclusions: The authors of this paper contend that effective methods of coping with stress, including mindfulness, should be considered as an additional subject in the final years of medical education.

Key words: mindfulness, psychiatry, stress, situational awareness, executive functions.

INTRODUCTION

Recently, the academic medical education community has drawn particular attention to the slightly increasing number of medical errors, which are mostly made by young physicians [1, 2]. Despite the increased access to medical knowledge and the use of gradually improved modern diagnostic techniques, the number of adverse events remains at a consistently high level. A possible explanation for this situation is the inadequate verification of information, especially by young physicians [3-6]. On the other hand, the direct cause of incorrect data processing may be excessive experience of stressful situations that occur in the early years of their work.

The role of stress

Stress can have both enhancing and debilitating effects on the functioning of the body, especially on learning, remembering, maintaining concentration and focus [7]. A negative reaction to stress causes impaired concentration, which increases the risk of serious consequences, especially among physicians. This is often behind a failure to recognize significant symptoms, which is especially important when they threaten the lives of patients [8].

On the other hand, there are experienced physicians who, due to their experience and gradual, systematic integration of acquired knowledge, show greater attention and concentration [9]. By using certain patterns developed over the years, their patient presentations tend to be more comprehensive and accurate. This often results in fewer mistakes being made by experienced physicians [10]. Therefore, methods are sought to increase focus and concentration to compensate for the initial lack of experience in the group of young doctors. Due to the high emotional stress they experience in the early years of work, stress management techniques can be effective.

Mindfulness as an effective method of coping with stress

Such method could reduce the negative impact of stress on the work of young doctors and thus reduce medical errors. One of the techniques for dealing with stress is mindfulness, which is the process of an individual intentionally focusing all their attention on the moment with curiosity, openness, and acceptance of each experience without judgment [11]. Mindfulness meditation reduces stress levels, positively affects executive functions (EF), and increases situational awareness (SA) in practitioners. Therefore, we posed the following key questions: To what extent does the stress experienced by young doctors influence their practice? Is mindfulness an effective method of reducing anxiety levels, and does it improve situational awareness, thus reducing the number of mistakes made? And finally, can we use the knowledge gained by exploring these questions to improve medical education? So far, no one has taken up such a topic, and there is a small amount of data evaluating the impact of mindfulness from the perspective of medical education. Moreover, from the patient's point of view this is an extremely important issue, which can improve their safety and, as a result, reduce the financial consequences of possible medical errors.

Review of published studies

To answer the questions posed above, an analysis of published research papers has been conducted. In our search we have mainly focused on the effects of stress, mindfulness, situational awareness, and executive function on young physicians' decision-making. **sTRess**

Undoubtedly, an important aspect that plays a key role in managing our behavior is stress. It is a non-specific reaction of the body to any demands placed on it by the environment, which are associated with both pleasant and unpleasant events for the individual [12]. Whether stress mobilizes and helps us, or affects us negatively, depends on our ability to manage it. The point at which the level of stress experienced is disturbing and becomes pathological is an individualized factor that can be influenced by a variety of circumstances [13]. In addition to innate, natural mechanisms there are scientifically validated techniques for coping with stress, the learning of which can be effectively used by both patients and medical staff [14]. Both chronic, prolonged stress and temporary but highly intense stress cause noticeable physiological changes, during which

hormone levels also change [7]. This is due to, among other things, the activation of the hypothalamic-pituitary-adrenal axis and the autonomic nervous system (ANS) [15]. This in turn has a direct impact on the functioning of the body. It improves its functioning, by increasing metabolic activity, or weakens it when defense mechanisms become exhausted.

The impact of stress on medical staff

The professional groups that enjoy public trust are particularly exposed to the negative effects of stress, including physicians who work in an intense, chaotic and unpredictable environment [16]. During their work in a hospital they are forced to make quick and important decisions that are always accompanied by stress, which through biological effects also indirectly affects the EF this mainly concerns attention and memory. Lack of attention increases the risk of serious consequences such as medical errors, failure to recognize life-threatening signs and symptoms, and other important patient safety issues [8].

Coping strategies

According to Lazarus and Folkman's relational theory, coping with stress involves an individual's ever-changing cognitive and behavioral effort to control specific demands that are judged to be a burden or exceed their resources [17]. Effective coping, which is expressed in a good match between demands and opportunities, reduces the state of stress. In contrast, ineffective coping leads to an increase in stress. The literature presenting the issue of coping with stress distinguishes three concepts with which to describe this phenomenon. These are: process, strategy and style. The process of coping with stress is a sequence of strategies that change over time, but is also genetically determined. Of particular relevance among physicians, problem-focused coping seems to describe an action-oriented style of coping with stress. Such individuals focus on a task or the planning of a solution to a problem. The style of coping with stress is on the one hand genetically determined, while on the other it is possible to some extent to modify abnormal mechanisms and reactions. Identification of the stress coping styles used among medical students is particularly important, as this is the right time to possibly work on reactions and behaviors. This is an extremely important aspect of medical education, which, in addition to the substantive knowledge of future doctors, can benefit both specific individuals and society as a whole. Therefore, timely education on methods of coping with stress is particularly important in this case.

Mindfulness

Due to the accelerating pace of work and increasing number of stimuli, to which people are now subjected it is observed that in general the quality of mental life decreases [18]. This leads to an increase in the incidence of depression, the emergence of burnout syndrome and decline in empathy and ethical reasoning, which becomes apparent even during the early years of work [19]. This concerns physicians, academics, students and other non-medical staff. In response to this phenomenon, effective relaxation methods are being sought.

What is mindfulness?

Mindfulness practice is one of the effective methods used by health care professionals to reduce stress. Mindfulness is a skill in which a person is directly focusing on a particular moment or a particular issue, and approaches it with openness and acceptance [20]. The practice of mindfulness leads to a conscious response to difficult situations, turning off negative automatisms. So mindfulness is consistent with the primary goal of medical practice: to treat illness when possible and to manage suffering in a compassionate way.

The impact of mindfulness on medical staff

In a study involving medical students, it was shown that being mindful is directly related to the reduction of stress and anxiety. In addition, it improves mood and increases empathy levels [21]. This is also supported by a meta-analysis involving 19 studies on the use of mindfulness among medical students [22]. Thus, mindfulness training appears to be an effective way to reduce stress among healthcare professionals [23]. It is

a very important skill in coping with daily functioning in a hospital environment [24]. In addition, mindfulness can increase the ability to detect and correct one's own mistakes, which considering the number of difficult decisions to be made is extremely important. The ability to experience without judging can also improve collaboration in medical teams and thus improve the performance of those teams in which it is practiced. Communication errors in medical teams are a common cause of subsequent medical errors [25]. The mitigating effects of practicing mindfulness may be particularly useful in the early years of practice, when young physicians are particularly exposed to a multitude of new stimuli and the resulting severe stress. On the other hand, there are also studies that do not support the effectiveness of mindfulness in reducing mental stress among college students, due to the existence of inconsistent reports regarding the use of the Maslach Burnout Inventory (MBI) and in response to appeals from other authors [26].

Situational Awareness

The importance of situational awareness among medical staff

Clinical reasoning, which requires identifying the basic elements of SA, is extremely important in the initial stages of working with patients. Recent and emerging research suggests that medical students have little insight into cognitive processing and SA [27]. Furthermore, SA is identified as one of the critical elements influencing medical practice [28], while the WHO has classified inadequate SA as a core parameter influencing inadequate clinical performance [29]. Situational awareness is the perception of individual elements of the environment with respect to the time and space in which they are located and their projection into the future. It belongs to the set of mechanisms via which we make decisions, thus conditioning purposeful, effective action. Loss of SA often occurs in situations where we experience unexpected, severe stress. Such moments are often experienced by medical professionals when treating critically ill patients [30]. Due to the lack of a universally accepted method, assessing situational awareness in medicine is extremely difficult. Fisher *et al*., reviewing the literature on the subject, suggest the use of Objective Structured Clinical Examinations (OSCEs) to assess individual elements of SA [31]. This is done through the use of medical simulations involving a holistic assessment of the student's clinical management relative to a case. To improve the clinical performance of young physicians and reduce medical errors, strengthening SA should be a key element [32, 33]. Moreover, SA should be reinforced as early as possible in the patient workflow, especially during medical education. Given the particular exposure to such situations among physicians, the question arises as to how to improve SA so that the stress of treating patients does not negatively affect young physicians.

Mindfulness as a method for improving situational awareness

Therefore, it is worthwhile to look for methods to improve SA and reduce stress. This is especially important among young physicians when the intensity of new stressful situations is strongest. The small number of studies conducted to date suggest that mindfulness practice is partially related to SA. It is primarily related to the taking of information during the case history, physical examination and the interpretation of additional tests. This is the first stage of a patient's treatment, where mindfulness is especially needed. In addition, the authors have shown that mindfulness is associated with certain non-technical skills in medical students, i.e., avoiding fixation-error during pediatric emergency simulations [34]. This evidence suggests that mindfulness can enhance medical students' ability to focus and concentrate by increasing present-moment awareness in pediatric emergencies [35]. Mindfulness practice appears to be a potentially effective method for improving SA, thereby reducing the number of medical errors. However, further research is required, specifically examining SA before and after an intervention such as mindfulness.

Executive functions

The importance of executive functions among medical staff

Executive functions are a set of specific processes that are responsible for directing, managing, and initiating specific behaviors. They are especially important while dealing with new and difficult situations that involve unexpected stress [36]. Research has shown that executive functions may be related to cognitive thinking, which is essential for proper clinical management by physicians. Studies on health care workers have found that occupational burnout is associated with EF impairments, particularly in inhibition, working memory, and decision making [37]. EF impairment makes it difficult to cope with new situations, causes difficulty in focusing attention [38], consequently reduce the productivity of medical workers [39, 40], and leads to potential medical errors. On the other hand, well-developed executive functions ensure effective planning, goal setting, the flexible changing of action strategies, and efficient problem solving. They are also responsible for non-technical skills. These are skills that facilitate effective communication with patients. Research reports have shown that implementation of non-technical skills (NTS) was associated with noticeable improvements in clinical outcomes. Study participants reported increased confidence in dealing with the deteriorating clinical conditions of patients [41]. There have also been numerous scientific calls for the introduction of NTS teaching to the medical school curriculum with the aim of, among other things, improving team communication and consequently reducing medical errors [42].

Mindfulness as a method for improving executive functions

Therefore, effective ways of improving EF are being sought, thereby increasing non-technical skills [43] among young physicians and medical students. Practicing mindfulness by improving non-technical skills [44] leads to increased professionalism among students and young doctors. Moreover, it improves awareness of one's own limitations, facilitates prioritization, and thus enables effective help-seeking when needed [45]. Previously published studies have demonstrated that mindfulness meditation has led to improved executive functioning and increased levels of critical thinking [46].

Department of medical simulations project

In addition, we share here our experience of teaching the 6th (final) year medical students from 2017 to 2021. During high-fidelity simulations more than 600 students played the role of an attending physician at least once in each of the 2 semesters. During the classes at the Department of Medical Simulations, students had the opportunity to play the role of a doctor for the first time, fully on their own. They had to independently make decisions about the diagnosis and treatment of the patient. Over the years, we analyzed the impact of mindfulness, executive functions, and stress on the therapeutic outcomes they achieved.

Conclusions from our experience

Conclusions from our study describe the effects of stress, mindfulness and executive function on the behavior and skills displayed by students during the simulation. In our study, stress was milder and more motivating the more attentive the students were. Students' mindfulness correlated positively with avoidance of fixation error [47]. In addition, the non-technical skills of the student group leaders improved with each simulation, while technical skills remained at the same level. We also noted that lack of reactivity, a component of mindfulness, was related to accurate collection of patient data from the medical history [48].

The Objective structured clinical exams project

In addition, there has been a recent change in medical exams; in addition to the typical theoretical knowledge, medical students are evaluated on their performance in practice. This uses more realistic, structured methods such as Objective Structured Clinical Exams (OSCE) [49]. Moreover, during such examinations other essential physician characteristics such as patient communication

skills, student professionalism, and situational awareness are assessed. There are studies that confirm the potential of OSCE as an effective didactic method of improving SA during medical education [50-53]. In our center, we plan to continue research on the effects of mindfulness, stress, situational awareness and executive functions on the basis of the results achieved during these exams.

Discusion

Mindfulness has been presented here as one of the effective methods of coping with stress. The beneficial effects of mindfulness techniques affect EF and SA, which can directly reduce medical errors.

The authors emphasize that SA is a key component of effective clinical intervention, especially in the early years of practice. Effective methods for improving SA include practicing mindfulness, which results in fewer errors. Another important aspect is EF – specific qualities that support effective action and decision-making. They are particularly important in NTS, the teaching of which is undeniably needed. Mindfulness practice can serve to educate NTS, thereby influencing EF and SA, which can often be sources of medical errors.

The aforementioned aspects are extremely important factors affecting the way physicians function in their professional lives. This is especially important and worthy of attention among young people during their education. Paying attention to these often overlooked issues during medical education could have a measurable impact on medical staff and, consequently, on their future patients. By learning to cope with stress, improving situational awareness and executive function, the frequency of an individual's errors can be reduced.

The paper presents high-fidelity medical simulation as a modern way of teaching that not only enhances content knowledge, but also prepares students for the specific stressors they are sure to experience in their careers. Simulation centers could become a place for medical students to learn mindfulness techniques, to consciously recognize the space between stimulus and response, and to respond to triggers, especially high-stress ones. Simulation scenarios include technical skills, such as diagnostic and therapeutic procedures, and non-technical skills. Therefore, high-fidelity simulation should be used to teach virtually all aspects of emergency care. In addition to this, high-fidelity simulations are an increasingly common method of teaching NTS. Learning to practice mindfulness techniques, on the other hand, provides a tool for distancing oneself from a stressful work environment, which can positively affect objective assessment of a clinical situation.

The above conclusions are supported by both our experience and the studies available in the literature. In one such study by Marker *et al*., as in our group, repetition of the simulation improved non-technical skills such as communication, teamwork, situational awareness and decision-making [51]. Clarke *et al*. showed, however, that the only variable affecting the overall rating of non-technical skills during the simulation (assessed with the GRS Ottawa) was the physicians' clinical experience, not stress or its subjective perception [52]. This can be explained because stress management skills, SA or EF were not included in this study. As the authors of the study showed, mindfulness training can be adapted and incorporated into modern medical teaching with relative ease. Focusing on the present moment can help young doctors honein on what is really important, which can include helping patients as well as themselves. The goal of mindfulness is to enable health care professionals to maintain distance from a mentally and emotionally stressful environment. Mistakes of fixation lead to adverse events; therefore, highly developed degree of SA among emergency medical teams leads to the avoidance of fixation errors and the correct diagnosis and treatment [53].

Considering the practice of mindfulness in medical education and the daily work of doctors, it is also very important to be aware of potential problems and risks. First of all, when teaching mindfulness techniques in medical school, attention should be paid to aspects such as the individual experience of stress, and students' situational awareness and executive functions. It should be noted that there is a risk of increased

stress, in some students who are predisposed to it, in the early stages of

mindfulness practice. Individuals who gain greater self-awareness during such practice may become too focused on their own experiences and become overly controlling, which may end up with job burnout greater than without mindfulness. Second, attention should be paid to the technical aspect of teaching mindfulness. It is extremely important to use validated, accurate mindfulness questionnaires [27]. Another important point is that a mindfulness instructor should be certified and continually expand his or her competence in certified centers. However, it should be emphasized that in addition to mindfulness, there are other methods that are also effective in dealing with stress.

Conclusions

To summarize the current scientific reports mentioned above and our own experience, mindfulness is an effective stress reduction technique that can improve SA and EF. Further multicenter studies in this area may show whether this will translate into fewer medical errors. The search for new teaching techniques is widening. Effective teaching methods include Medical Simulation Centers and OSCE exams. In the opinion of the authors of this publication, teaching mindfulness techniques as an optional subject in medical studies should be considered, and thus further research based on the results and opinions of students should be undertaken.

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Oświadczenia współautorów

Włodzimierz Łuczyński
imię i nazwisko współautora

Białystok, 23.01.2023
miejscowość, data

Zakład Symulacji Medycznych
nazwa jednostki

Uniwersytet Medyczny w Białymstoku
ul. J. Kilińskiego 1
15-089 Białystok

Oświadczenie

Oświadczam, iż mój udział w przygotowaniu publikacji:

„Relationship between executive functions, mindfulness, stress, and performance in pediatric emergency simulations" autorów: Łoś Kacper, Chmielewski Jacek, Łuczyński Włodzimierz, opublikowanej w International Journal of Environmental Research and Public Health, wchodzącej w skład rozprawy doktorskiej „Mindfulness (uważność), stres, funkcje wykonawcze jako cechy wpływające na efekty działania studentów kierunku lekarskiego w symulacjach medycznych", wynoszący 30 % polegał na: zaprojektowaniu, pisaniu pracy, analizie zebranych wyników.

Jednocześnie wyrażam zgodę na wykorzystanie przez Kacpra Łoś publikacji w postępowaniu o nadanie stopnia doktora w dziedzinie nauk medycznych i nauk o zdrowiu w dyscyplinie nauki medyczne.

[Podpis]
Włodzimierz Łuczyński

Chmielewski Jacek
imię i nazwisko współautora

Białystok, 06.12.2022
miejscowość, data

Klinika Psychiatrii UMB
nazwa jednostki

Uniwersytet Medyczny w Białymstoku
ul. J. Kilińskiego 1
15-089 Białystok

Oświadczenie

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[Podpis]

Jacek Chmielewski

Włodzimierz Łuczyński
imię i nazwisko współautora

Zakład Symulacji Medycznych
nazwa jednostki

Białystok, 23.01.2023
miejscowość, data

Uniwersytet Medyczny w Białymstoku
ul. J. Kilińskiego 1
15-089 Białystok

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[Podpis]

Włodzimierz Łuczyński

Napoleon Waszkiewicz
imię i nazwisko współautora

Klinika Psychiatrii UMB
nazwa jednostki

Białystok, 06.12.2022
miejscowość, data

Uniwersytet Medyczny w Białymstoku
ul. J. Kilińskiego 1
15-089 Białystok

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Jednocześnie wyrażam zgodę na wykorzystanie przez Kacpra Łoś publikacji w postępowaniu o nadanie stopnia doktora w dziedzinie nauk medycznych i nauk o zdrowiu w dyscyplinie nauki medyczne.

[Podpis]

Informacja o charakterze udziału współautorów w publikacjach wraz z szacunkowym określeniem procentowego wkładu

„Relationship between executive functions, mindfulness, stress, and performance in pediatric emergency simulations." **Łoś Kacper,** Chmielewski Jacek, Łuczyński Włodzimierz. International Journal of Environmental Research and Public Health: 2020 : 17, 6, 10 pp., Article ID 2040.

Imię i nazwisko współautora	Charakter udziału	Procentowy wkład
doktorant - lek. Kacper Łoś	udział w koncepcji badania, udział we wszystkich etapach badania, analiza danych statystycznych, przygotowanie manuskryptu	60%
Prof. dr hab. Włodzimierz Łuczyński	zaprojektowaniu, pisaniu pracy, analizie zebranych wyników	30%
mgr Jacek Chmielewski	zaprojektowaniu pracy	10%

„Can the practice of mindfulness reduce medical errors?" **Łoś Kacper,** Łuczyński Włodzimierz., Waszkiewicz Napoleon. Postepy Psychiatrii i Neurologii: 2022 : 31, 3, 7 pp.

Imię i nazwisko współautora	Charakter udziału	Procentowy wkład
doktorant - lek. Kacper Łoś	koncepcja pracy, przegląd piśmiennictwa, przygotowanie manuskryptu	80%
Prof. dr hab. Włodzimierz Łuczyński	merytoryczna ocena pracy	10%
Prof. dr hab. Napoleon Waszkiewicz	merytoryczna ocena pracy	10%

Oświadczam, że wszyscy współautorzy wyrazili zgodę na wykorzystanie powyższej publikacji w pracy doktorskiej lek. Kacpra Losia

Podpis

Łoś Kacper

Białystok, 25-10-2018

Uchwała nr: R-I-002/405/2018

Komisja Bioetyczna Uniwersytetu Medycznego w Białymstoku, po zapoznaniu się z projektem badania zgodnie z zasadami GCP/ Guidelines for Good Clinical Practice /- **w y r a ż a z g o d ę** na prowadzenie tematu badawczego: „Cechy uważności (mindfulness) oraz funkcje wykonawcze w prognozowaniu umiejętności nie-technicznych studentów w trakcie symulacji medycznych wysokiej wierności w pediatrii" przez prof. dr hab. Włodzimierza Łuczyńskiego wraz z zespołem badawczym z UMB.

Z-ca Przewodniczącej Komisji Bioetycznej UMB
dr n. farm. Krzysztof Chrzanowski

Zaświadcza się, że Pani Kacper Kość jest członkiem zespołu badawczego powyższego projektu.

UNIWERSYTET MEDYCZNY
w Białymstoku
KOMISJA BIOETYCZNA
15-089 Białystok, ul. Jana Kilińskiego 1