OFP

Osteopathic Family Physician

THE OFFICIAL PEER-REVIEWED PUBLICATION OF THE AMERICAN COLLEGE OF OSTEOPATHIC FAMILY PHYSICIANS

JULY | AUGUST 2022

Volume 14 | Number 4

ofpjournal.com

acofp | AMERICAN COLLEGE OF OSTEOPATHIC FAMILY PHYSICIANS

www.acofp.org

Guide for

READERS

Osteopathic Family Physician (ISSN 1877-573X) is published bimonthly by the American College of Osteopathic Family Physicians. Postage paid at Arlington Heights, IL, and additional mailing offices.

USA POSTMASTER

Send address changes to:

American College of Osteopathic Family Physicians
Membership Department:

330 E. Algonquin Rd., Ste. 1
Arlington Heights, IL, 60005

CUSTOMER SERVICE

(orders, claims, online, change of address)

American College of Osteopathic Family Physicians

330 E. Algonquin Rd., Ste. 1
Arlington Heights, IL 60005

847-952-5100 | membership@acofp.org

YEARLY SUBSCRIPTION RATES

United States & Possessions:

Individual $116 | Institution $208 | Student $57

All other countries: *(prices include airspeed delivery)*

Individual $146 | Institution $267 | Student $74
Single issues $42

To receive student rate, orders must be accompanied by name of affiliated institution, date of term and signature of program coordinator on institution letterhead. Orders will be billed at the individual rate until proof of status is received. Current prices are in effect for back volumes and back issues.

ADVERTISING INFORMATION:

Advertising orders and inquiries can be sent to:

Matt Van Wie
804-550-2312 | matt@esvw.com

AUTHOR INQUIRIES

For inquiries relating to the submission of articles (including electronic submission), please visit www.ofpjournal.com.

Content details for questions arising after acceptance of an article, especially those relating to proofs, will be provided by the publisher.

You can track accepted articles and view Author Guidelines through Scholar One at mc04.manuscriptcentral.com/ofp.

The paper used in this publication meets the requirements of ANSI/NISO Z39.48-1992 (Permanence of Paper).

AUTHORS

For a full and complete Guide for Authors, please go to: mc04.manuscriptcentral.com/ofp.

REPRINTS:

For queries about author reprints, or to order 100 or more reprints for education, commercial or promotional use, contact ACOFP at 847-952-5100 or email gracea@acofp.org.

OFP
Osteopathic Family Physician
The Official Peer-Reviewed Publication of the
American College of Osteopathic Family Physicians

OSTEOPATHIC FAMILY PHYSICIAN SPECIALTY PEER REVIEWERS

Nazem Abdelfattah, DO
Family Medicine

Jeffrey Benseler, DO
Radiology

Franklin Berkey, DO, FAAFP
Cancer, Cardiovascular, Hospice and Palliative Care, GME

Shagun Bindlish, MD
Diabetes and Endocrinology

Raj Brar, DO
Behavioral Health, Family Medicine, Geriatrics, OMT, Pain Management, Pediatrics

Natasha Bray, DO
Ethics

Mohammad Bukhari, DO
Family Medicine, Obstetrics

Janis Coffin, DO
Practice Management

Andrew Crow, DO
Academic, Emergency, Hospital Care, Military

Daniel Jason Frasca, DO
Behavioral Health, Addiction Medicine, Nutrition, Hypertension, Renal Disorders

Ron Grubb, DO
Diabetes, Sports Medicine

Steve Kamajian, DO, CMD, FACOFP
Family Medicine, Geriatrics, Long Term Care

Frank Komara, DO, FACOFP
Geriatrics

Mana Lazzaroto, DO
Clinical Images

Ehab Mady, DO
Vascular

Donald Morgan, DO
Family Medicine

Marjan Moghaddam, DO
Family Medicine

Jon Parham, DO
Preventive Medicine, Pulmonary, Public Health, Geriatrics, Medical Errors

Nicholas Pennings, DO, FOMA
Obesity

Raena Pettitt, DO
Disease Prevention & Wellness

Kim Pfotenhauer, DO
Diabetes

M. Jay Porcelli, DO, MEd, PhD, FACOFP *dist.*
Pain Management

Jill Yurko Porter, DO
Obesity, OMT, Physician Wellness and Women's Health

Chad Richmond, DO
Emergency, Family Medicine, Outpatient

Bernadette Riley, DO, FACOFP
Medical Education, Academic, Simulation Medicine, Physician Leadership, Health Policy

Mark Rogers, DO, MA, CAQSM, FAAFP
Family Medicine, Sports Medicine, OMM, Medical Ethics

Kary Schroyer, DO
Direct Primary Care

Christopher Scuderi, DO
Family Practice, Practice Management

Leslie Sleuwen, MD
Community Medicine

Johnathon Torres, DO, FACOFP
OMM

Chad Uptigrove, DO
OMM Obstetrics, Residency Training

Julian Vega, DO
Clinical Images

Sheldon Yao, DO
Cardiology

STUDENT AND RESIDENT PEER REVIEW INTERNS

Habiba Ahasan, OMS-I
New York Institute of Technology College of Osteopathic Medicine

Trudy-Ann Alston, DO
Philadelphia College of Osteopathic Medicine- Georgia

Melissa Anderson-Chavarria, DO, PhD Candidate
Michigan State University College of Osteopathic Medicine

Joseph A. Barber, OMS-III
Alabama College of Osteopathic Medicine

Sophia Barber, OMS-III
Kansas City University College of Osteopathic Medicine

Nicole Marie Barcega, OMS-III
Western University of Health Sciences - College of Osteopathic Medicine of the Pacific

Alyssa Benjamin OMS-III
Nova Southeastern University Dr. Kiran C. Patel College of Osteopathic Medicine

Shrishti Bhattarai, OMS-II
Arkansas College of Osteopathic Medicine

Jocelyn Canedo, OMS-III
Edward Via College of Osteopathic Medicine-Auburn

Andrew Chandler, OMS-III
Touro College of Osteopathic Medicine

Steve Collins, OMS-III
Midwestern University Arizona College of Osteopathic Medicine

Cara Conrad, OMS-III
A.T. Still University - Kirksville College of Osteopathic Medicine

Molly Cunard, OMS-III
Des Moines University College of Osteopathic Medicine

Brianna Custer, OMS-III
Liberty University College of Osteopathic Medicine

Abby Davis, OMS-I
Oklahoma State University - College of Osteopathic Medicine

James Docherty, DO
United Health Services

Alice Doong, DO
St. Mary Mercy Livonia Hospitall

Renee El-Khoury, DO
Midwestern University Arizona College of Osteopathic Medicine

Atif Farid, OMS-I
New York Institute of Technology College of Osteopathic Medicine

Abigail Ferrell, OMS-I
Lake Erie College of Osteopathic Medicine

Sagufta Garasia, OMS-I
Sam Houston State University School of Osteopathic Medicine

Miranda Guerriero OMS-III
Lake Erie College of Osteopathic Medicine

Carina Harrison, OMS-II
Kansas City University College of Osteopathic Medicine

Morgan Heitt, OMS-I
Oklahoma State University College of Osteopathic Medicine

Aubrey Ann Jackson, OMS-II
Liberty University College of Osteopathic Medicine

Cody Jackson, OMS-I
A.T. Still University - School of Osteopathic Medicine in Arizona

Filza Jalees, DO
United Memorial Medical Center

Monica Kavanaugh, MPH, OMS-I
A.T. Still University - Kirksville College of Osteopathic Medicine

Taylor Keiper, OMS-III
Edward Via College of Osteopathic Medicine-Virginia

Cindy Kim, OMS-II
Western University of Health Sciences - College of Osteopathic Medicine of the Pacific

Gabriel Koch, OMS-I
Western University of Health Sciences - College of Osteopathic Medicine of the Pacific

Liana Kobayashi, DO
University of Hawaii Family Medicine Residency Program

Valeriya Korchina, DO
Des Moines University College of Osteopathic Medicine

Matthew Knapp, OMS-I
Lake Erie College of Osteopathic Medicine

Gregory Kunis, OMS-III
Nova Southeastern University Dr. Kiran C. Patel College of Osteopathic Medicine

Katie Lamar, OMS-III
Nova Southeastern University Dr. Kiran C. Patel College of Osteopathic Medicine

Adrienne Law, MS, DO
Franciscan St. James Hospital

Robert Lemme, OMS-IV
A.T. Still University - Kirksville College of Osteopathic Medicine

Jacob Lenz, OMS-II
A.T. Still University - Kirksville College of Osteopathic Medicine

Jonathan Letko, OMS-IV
Michigan State University College of Osteopathic Medicine

Samantha Long, MS, OMS-IV
Ohio University Heritage College of Osteopathic Medicine

Katherine Loomba, OMS-III
New York Institute of Technology College of Osteopathic Medicine

Karstan Luchini, OMS-II
Kansas City University Joplin

Victoria Ly, OMS-I
William Carey University College of Osteopathic Medicine

Briana Martiszus, OMS-I
Western University of Health Sciences - College of Osteopathic Medicine of the Pacific

Simran Mehrotra, OMS-I
William Carey University - School of Osteopathic Medicine

Amy McMellon, OMS-III
Arkansas College of Osteopathic Medicine

Nabeth A. Midley, OMS-II
Michigan State University - College of Osteopathic Medicine

Donielle Miller-Hesse, OMS-II
Western University of Health Sciences - College of Osteopathic Medicine of the Pacific

Yasamin Mohammadi, OMS-III
Kansas City University College of Osteopathic Medicine

Sarah Jane Muder, OMS-II
New York Institute of Technology College of Osteopathic Medicine

Kaleigh Mullen, OMS-IV
Kansas City University College of Osteopathic Medicine

Diem My Hoang, OMS-I
Touro University College of Osteopathic Medicine in California

Ke (Kevin) Ma, OMS-I
William Carey University College of Osteopathic Medicine

Truc Nguyen, OMS-III
Nova Southeastern University Dr. Kiran C. Patel College of Osteopathic Medicine

Awais Ur Rahman, OMS-II
Kansas City University College of Osteopathic Medicine

Aarthi Ramesh, OMS-III
Kansas City University College of Osteopathic Medicine

Daniel Resnick, OMS-I
Western University of Health Sciences - College of Osteopathic Medicine of the Pacific

Erica Romo, OMS-III
Rocky Vista University College of Osteopathic Medicine

Ammie Rupani, OMS-I
Sam Houston State University College of Osteopathic Medicine

Heemani Ruparel, OMS-III
Rowan University School of Osteopathic Medicine

Shalini Sakhamuri, OMS-III
Edward Via College of Osteopathic Medicine

Aparna Sankar, OMS-III
Texas College of Osteopathic Medicine

Shayan Shiehzadegan, OMS-III
Western University of Health Sciences - College of Osteopathic Medicine of the Pacific

Nisarg Shah, OMS-IV
Nova Southeastern University Dr. Kiran C. Patel College of Osteopathic Medicine

Mark Shokralla, OMS-I
William Carey University College of Osteopathic Medicine

Haley Spector, OMS-I
Des Moines University College of Osteopathic Medicine

Bahadar Singh Srichawla, OMS-IV,
Touro College of Osteopathic Medicine - Middletown

Austen Smith, DO
Firelands Regional Medical Center

Evan Starr, OMS-I
Rocky Vista University College of Osteopathic Medicine - Southern Utah

Gayatri Susarla, OMS-I
New York Institute of Technology College of Osteopathic Medicine

Colleen Szypko, OMS-I
New York Institute of Technology College of Osteopathic Medicine

McKenna Tierney, OMS-III
Nova Southeastern University Dr. Kiran C. Patel College of Osteopathic Medicine

Taylor Totterdale, OMS-II,
Kansas City University College of Osteopathic Medicine

Johnny Voigt, OMS-I
New York Institute of Technology College of Osteopathic Medicine

Niven Wang, OMS-I
Sam Houston State University College of Osteopathic Medicine

Brandon Wolters, OMS-I
Ohio University Heritage College of Osteopathic Medicine

Kevin Wortman II, OMS-III
Edward Via College of Osteopathic Medicine - Auburn

Wei-Jen Yankelevich, PhD, OMS-IV
Michigan State University College of Osteopathic Medicine

Zachary A. Wright, OMS-III
Arizona College of Osteopathic Medicine

Tiffany Zai, MPH, OMS-II
Touro University College of Osteopathic Medicine in California

Kylie Zeng, OMS-II
Touro University Nevada College of Osteopathic Medicine

JULY/AUGUST 2022
VOLUME 14 | NUMBER 4

CONTENTS

EDITOR'S MESSAGE

The Physician's Voice

Paula Gregory, DO, MBA, FACOFP

The hot winds of spring and summer are upon us, storms and weather warnings abound. Tempers flare and misunderstandings are escalated. Across the United States, our patients and communities have been impacted by domestic violence, gun violence and weather disasters, while being terrorized by viruses.

Primary care physicians (PCPs) are leaders in the community—rural and urban—and the first person who recognizes, advises and understands the patient, family and community in which they serve. They have been described as the one respected voice in the community and are often asked the "real" patient questions as they exit the room—the doorknob conversation during which patients pose statements like "Doctor, my daughter is not doing well in school," or "Doctor, I'm worried about my husband's drinking." Your voice is sought to decide if this is normal or needs attention. You are often asked not only to evaluate but also to decide what course of treatment is needed, and often, these issues involve emotional or mental health issues. In fact, PCP intervention over a 10-year period (1987–1997) shows an increase from 37.3% to 74.5% in medications prescribed for depression.

You see signs of stress, job and school issues, mental illness, and domestic violence on top of the other serious diseases patients are fighting daily. Your skill in the room keeps your patients on the path of healthier behaviors while fighting for their lives. Your advice resonates with patients and the physicians' words are some of the most respected words in the community, and when disaster strikes, you are the first to volunteer and to be available to help your community. We have seen in rural and urban areas the disaster that has happened with gun violence and weather-related incidents; the physician's hope is to be able to understand and intervene both before and as disaster happens. Once disaster strikes, it is not over in a day or a week; it can last a lifetime for our patients, families and communities.

As you navigate the weather of summer, your cool-headed advice and voice can help many cope with uncertainty and create solutions that fit, whether deescalating a misunderstanding, directing a patient to a needed service or just listening to emotional cries.

FROM THE PRESIDENT'S DESK

A Call to Serve

Bruce R. Williams, DO, FACOFP

I have been asked, "How did you become involved in ACOFP?" The very short answer is simple: **I was asked**.

When I was a medical school student in Kansas City, I began looking at leaders in my class and at my school, as well as local, state and national leaders. Many of these leaders were the same person. What made them so special? Why were they sought after? What was their motivation? Why did I care?

I cared because these were the individuals who were driving the evolution of our profession—a profession and a philosophy that I believed in and embraced. I wanted to be part of that evolution, and I wanted to know what my role was, which I discovered as I studied the osteopathic oath. I was meant to advocate for my patient through my involvement in organized medicine.

After graduating from what is now Kansas City University College of Osteopathic Medicine; completing my internship; and beginning practice, one of my first goals was to seek out Jackson County Osteopathic Medical Association President William Betz, DO, and ask him for an application. From there, I attended meetings, and **I was asked** to sit on the Board of Governors. I was honored to be asked, and I expressed my willingness and commitment.

After my involvement in my district, **I was asked** to sit on a state committee. I again was honored and embraced the opportunity to make an impact at the state level. Eventually, **I was asked** to join the executive committee of the Missouri Association of Osteopathic Physicians and Surgeons (MAOPS), becoming president in 2004.

As I continued to serve MAOPS, **I was asked** to join a committee for the Missouri Society of the ACOFP (MSACOFP). I had been a member since 1987 but not involved to a great degree due to my commitment with MAOPS. So I joined the Convention Committee and others. Then **I was asked** to become a delegate to the ACOFP Congress of Delegates.

After serving as a delegate and a committee member, **I was asked** to join the MSACOFP Executive Committee and later became MSACOFP president in 2011. As I attended the ACOFP Congress of Delegates, ACOFP Conventions & Scientific Seminars, ACOFP Intensive Update and Board Review (now Intensive Osteopathic Update) and OMED, I was advised to become an ACOFP Fellow by a few of my mentors—Wilbur Hill, DO, FACOFP *dist*.; Phil Accardo, DO FACOFP; Joe Yasso, DO, FACOFP; James DiRenna, Jr., DO, FAAFP; Alan Brewer, DO, FACOFP; and Elaine Joslyn, DO, FACOFP, among others—so I pursued that and became an ACOFP Fellow in 2012.

Then, I was encouraged by 2012–13 ACOFP President Paul Martin, DO, FACOFP *dist*., to seek a committee appointment. The following year, 2013–14 ACOFP President Jeff Grove, DO, FACOFP *dist*., discussed what committee(s) I should be appointed to, and the 2014–15 ACOFP President Carol Henwood, DO, FACOFP *dist*., approached me about serving on the ACOFP Board of Governors. In all of these instances by all of these leaders, **I was asked**.

My service and commitment to family medicine and the osteopathic profession is a labor of love. I believe our philosophy of the art of medicine provides our patients added opportunities for quality care at lower cost for improved patient and provider satisfaction. In the roles I have served, I have done my best to promote osteopathic medicine as the route to the quadruple aim. I believe we—the osteopathic profession—have demonstrated that. But, if I had not been asked, would I have come this far? Perhaps, but being the introvert that I am, perhaps not.

I have been honored and humbled to serve in the many roles I have served in for our profession. Yet, I have not taken these roles lightly. I have seen them and embraced them as an opportunity to make an impact for the profession I believe in and the patients I love.

What a privilege it is to be asked to serve. To be asked to be put in a position to advocate on behalf of your profession and your patients. To be seen as an individual whose experience, thoughts and opinions are respected enough to get the attention of a group who will collectively consider the best way to move forward for those we serve.

What a privilege it is to be asked to serve. To be asked to be put in a position to advocate on behalf of your profession and your patients. To be seen as an individual whose experience, thoughts and opinions are respected enough to get the attention of a group who will collectively consider the best way to move forward for those we serve. I have had the honor and privilege to serve with and for some of the finest and most respected physicians that not only the osteopathic profession, but also the entire medical profession, has ever known.

Now I serve you and the osteopathic family medicine community as president of the American College of Osteopathic Family Physicians. This is a most prestigious role and an awesome responsibility. I am the face and voice of the largest specialty in the osteopathic profession. I am very honored, and I am very humbled. I have never aspired to this role, yet I find myself here, and I have committed to serve to the very best of my ability.

I am so blessed, as well, because I am not serving alone. I have a committed and passionate Board of Governors and a dedicated staff team to support me. I also have the experience and advice from my predecessors to guide me. My goal is to move osteopathic family medicine forward for ACOFP, for the osteopathic profession, for our osteopathic family physicians and—most of all—for our patients.

I was asked, and now, I am asking you. Will you share your opinions, your time, your talents, your ideas, your passion, your enthusiasm and your resources with ACOFP? We want you, we need you and we are asking; I am asking: Will you serve?

Osteopathically yours,

Bruce R. Williams, DO, FACOFP

CALENDAR OF EVENTS

JULY 28–31, 2022
46th Annual CME Seminar & Convention
American College of Osteopathic Family Physicians of California
Anaheim, CA
acofpca.org

JULY 28–31, 2022
FSACOFP Annual Convention
Florida Society of the American College of Osteopathic Family Physicians
Orlando, FL
fsacofp.org

AUGUST 5–7, 2022
ACOFP Intensive Osteopathic Update
American College of Osteopathic Family Physicians
Rosemont, IL
acofp.org

AUGUST 5–7, 2022
47th Annual CME Symposium
Pennsylvania Osteopathic Family Physicians Society
Hershey, PA
poma.org

AUGUST 11–14, 2022
MAOFP 2022 Summer Family Medicine Update
Michigan Association of Osteopathic Family Physicians
Acme, MI
maofp.org

AUGUST 12–14, 2022
NCS-ACOFP Annual CME Conference
North Carolina Society of the ACOFP
Pinehurst, NC
nc-acofp.org

OCTOBER 27–30, 2022
OMED 2022
American College of Osteopathic Family Physicians
Boston, MA
omed.osteopathic.org

MARCH 29 – APRIL 2, 2023
ACOFP 60th Annual Convention & Scientific Seminars
American College of Osteopathic Family Physicians
Orlando, FL
acofp.org

CME Resource: *Osteopathic Family Physician* Offers 2 Hours of 1-B CME

ACOFP members who read *Osteopathic Family Physician* can receive two hours of Category 1-B continuing medical education credit for completing quizzes in the journal. Visit the eLearning center at www.acofp.org to access the quizzes.

REVIEW ARTICLE

2022 ADULT IMMUNIZATION SCHEDULE UPDATES

Stanley E. Grogg, DO, FACOP, FAAP

Oklahoma State University Center for Health Sciences, Tulsa, OK

KEYWORDS:

Adult immunization

COVID-19

Immunizations

Vaccination

Abstract

Each year, the U.S. Centers for Disease Control and Prevention (CDC) releases the adult vaccine schedule. The 2022 adult vaccine schedule has several changes which will be discussed in the following manuscript. The Advisory Committee on Immunization Practices reviews the preliminary schedules usually at their October or November meetings. The following professional societies also approve the adult schedules prior to the 2022 publications: American College of Physicians (ACP), American Academy of Family Physicians (AAFP), American College of Obstetricians and Gynecologists (ACOG), American College of Nurse-Midwives (ACNM), American Academy of Physician Assistants (AAPA) and the Society for Healthcare Epidemiology of America (SHEA). Once the final draft is approved by the CDC, it is published in the *Morbidity and Mortality Weekly* Report (MMWR) and released to healthcare providers and the general public with a cover page, tables, notes and—new for the 2022 schedule—an appendix with contraindications and precautions for the different approved vaccines.

INTRODUCTION

The 2022 adult vaccine schedue has several updates. The adult vaccines discussed in this article are listed in Figure 1, taken from the draft cover page of the 2022 immunization schedule shown in slide [53].1 In addition, the latest recommendations for COVID-19 immunization will be reviewed. Vaccines listed can be given at the same time including with the COVID-19 immunization, if indicated.[2]

A free app provided by the U.S. Centers for Disease Control and Prevention can be downloaded on smart phones to make finding recommended vaccines for specific ages and medical conditions quickly.[3] Adverse events to vaccines should be reported to Vaccine Adverse Event Reporting System (VAERS).[4]

FIGURE 1:

Adult Vaccines

VACCINE	ABBREVIATION(S)	TRADE NAME(S)
Haemophilus influenzae type B vaccine	Hib	ActHIB® Hiberix® PedvaxHIB®®
Hepatitis A vaccine	HepA	Havrix® Vaqta®
Hepatitis A and hepatitis B vaccine	HepA-HepB	Twinrix®
Hepatitis B vaccine	HepB	Engerix-B® Recombivax HB® Heplisav-B®
Human papillomavirus vaccine	HPV Vaccine	Gardasil 9®
Influenza vaccine (inactivated)	IIV4	Many brands
Influenza vaccine (live, attenuated)	LAIV4	FluMist® Quadrivalent
Influenza vaccine (recombinant)	RIV4	Flublok® Quadrivalent

CORRESPONDENCE:
Stanley E. Grogg, DO, FACOP, FAAP | stanley.grogg@okstate.edu

 Print ISSN: 1877-573X
doi:10.33181/13077

FIGURE 1 CONT'D:

Adult Vaccines

VACCINE	ABBREVIATION(S)	TRADE NAME(S)
Influenza vaccine (recombinant)	RIV4	Flublok® Quadrivalent
Measles, mumps, and rubella vaccine	MMR	M-M-R® II
Meningococcal serogroups A, C, W, Y vaccine	MenACWY-D MenACWY-CRM MenACWY-TT	Menactra® Menveo® MenQuadfi®
Meningococcal serogroup B vaccine	MenB-4C MenB-FHbp	Bexsero® Trumenba®
Pneumococcal 15-valent conjugate vaccine	PCV15	Vaxneuvance™
Pneumococcal 20-valent conjugate vaccine	PCV20	Prevnar 20™
Pneumococcal 23-valent polysaccharide vaccine	PPSV23	Pneumovax 23®
Tetanus and diphtheria toxoids	Td	Tenivac® Tdvax™
Tetanus and diphtheria toxoids and acellular pertussis vaccine	Tdap	Adacel® Boostrix®
Varicella vaccine	VAR	Varivax®
Zoster vaccine, recombinant	RZV	Shingrix

** Reprinted from the CDC website: a public domain website that is not subject to copyright and may be freely used or reproduced without obtaining copyright permission*

COVID-19

COVID-19 vaccines are recommended within the scope of the emergency use authorization (EUA) or biologics license application for a particular vaccine, or as recommended by the Advisory Committee on Immunization Practices (ACIP) and reviewed by the U.S. Center for Disease Control and Prevention's (CDC) Director and, if adopted, are published as official CDC and US. Department of Health and Human services (HHS) recommendations in the *Morbidity and Mortality Weekly* Report (MMWR).[5] The ACIP and CDC have issued interim recommendations for the use of following three COVID-19 vaccines: the Pfizer-BioNTech, now being marketed as Comirnaty,[6] vaccine for those aged 16 years and older, the Moderna vaccine for those aged 18 years and older and the Johnson & Johnson (J&J)/Janssen COVID-19 vaccines for those aged 18 years and older.[7] Booster vaccines are recommended for those 18 and older.[7] In most situations, Pfizer-BioNTech or Moderna vaccines are preferred over the J&J/Janssen vaccine for due to the rare event of thrombosis with thrombocytopenia syndrome (TTS) after J&J/Janssen COVID-19 vaccination;[8] however, the J&J/Janssen COVID-19 vaccine may be considered for persons who:

- Had a severe reaction after an mRNA vaccine dose or who have a severe allergy to an ingredient of Pfizer-BioNTech or Moderna (mRNA COVID-19 vaccines).
- Would otherwise remain unvaccinated for COVID-19 due to limited access to Pfizer-BioNTech or Moderna (mRNA COVID-19 vaccines).
- Wants to get the J&J/Janssen COVID-19 vaccine despite the safety concerns.

In general, the primary series and additional primary doses should be with the same vaccine product (ie, the same manufacturer). For people at least 18 years old, in situations in which the mRNA vaccine product given for the first dose of the primary series cannot be determined or is not available, any available mRNA COVID-19 vaccine product may be administered at a minimum interval of 28 days between doses to complete the mRNA COVID-19 vaccination series. If an individual received the first dose of an mRNA COVID-19 vaccine but is unable to complete the series with either the same or different mRNA COVID-19 vaccine (eg, due to contraindication), a single dose of J&J/Janssen COVID-19 vaccine may be considered at a minimum interval of 28 days from the previous mRNA COVID-19 vaccine dose if the person is at least 18 years old. People who receive the J&J/Janssen COVID-19 vaccine after a dose of an mRNA COVID-19 vaccine should be considered fully vaccinated against COVID-19 at least 2 weeks after receipt of the single dose of the Janssen vaccine.[9]

The ACIP/CDC also changed the interval for booster shots of Pfizer's vaccine in all individuals 12 and up to at least 5 months after the second dose (was previously 6 months). For the Pfizer-BioNTech or Moderna vaccines, those 18 years and older may recieve a booster dose if given at least 5 months after completing the primary series for the Pfizer-BioNTech or Moderna vaccines. If the one dose of the J&J/Janssen vaccine is given, and if 18 years of age and older, a booster at least 2 months after the initial immunization may be given. Any of the COVID-19 vaccines authorized in the US can be used for the booster.[10]

HAEMOPHILUS INFLUENZAE TYPE B

The *Haemophilus influenzae* type b (Hib) vaccine is not routinely recommended for healthy adults aged 19 years and older, even if the person did not receive Hib vaccine as a child. However,

the ACIP recommends that 1 dose of the Hib vaccine should be administered to persons who have anatomical or functional asplenia or sickle cell disease or are undergoing elective splenectomy if they have not previously received Hib vaccine. The Hib vaccine should be administered 14 or more days before splenectomy if possible. Recipients of a hematopoietic stem cell transplant should be vaccinated with a 3-dose series of Hib vaccine 6–12 months after a successful transplant, regardless of vaccination history, at least 4 weeks should separate doses. The Hib vaccine is not recommended for adults with HIV infection because their risk for Hib disease is low.[11]

HEPATITIS A

The hepatitis A vaccine (HEPA) is a 2-dose series. All high-risk patients with no documentation of HEPA should be given the immunization. Examples of persons who should have the HEPA include those with chronic liver disease or HIV; men who have sex with men (MSM); individuals who use injection or non-injection drug use; laboratory personnel working the hepatitis A virus; those traveling to countries with endemic hepatitis A; and those with close contact to international adoptees.[12] A special emphasis recently has been to vaccinate the homeless.[13]

HEPATITIS B

The hepatitis B virus (HBV) vaccine is recommended for all persons aged 19–59 years old if they have not received the series in the past. Those aged 60 and older should receive HBV series with any risk factors for HBV infections, including MSM; people who inject drugs; household contacts or sexual partners of known people with chronic HBV infection; health care and public safety workers at-risk for occupational exposure to blood or blood-contaminated body fluids; diabetics; and hemodialysis patients.[14] The World Health Organization and the CDC plan to eliminate HBV infections by 2030.[15] There are 2-, 3- and 4-dose series of HBV vaccines available for use.[16] A 2-dose series applies to the Heplisav-B vaccine by Dynavax, given at least 4 weeks apart. The 3-dose series includes Engerix-B by GSK; Recombivax HB by Merck; and the recently approved PreHevbrio by VBI Vaccines,[17] given at birth, 1 month and 6 months. Twinrix by GSK, a combination of Hep A and HBV, is a three-dose series at birth, 1 month and 6 months (regular dosing) or a four-dose series given at birth, 7 days and 21–30 days, with a booster dose at 12 months (accelerated dosing).[18]

HUMAN PAPILLOMAVIRUS

The human papillomavirus (HPV) vaccine is recommended for all adults aged 18–26 years if not adequately vaccinated in the past. Vaccination is not recommended for everyone older than 26. However, some adults aged 27–45 years may choose to receive the HPV vaccine based on a discussion with their clinician, if they did not get adequately vaccinated when younger.[19] For immunocompromising conditions—such as HIV infection—a 3-dose series is recommended when initiating vaccination at age 9–45 years.[20] Pregnancy testing is not needed before HPV vaccination but is not recommended during pregnancy, and no intervention needed if inadvertently vaccinated while pregnant.[21]

INFLUENZA

Routine influenza vaccination is indicated for those aged 19 years and older as an annual dose of any influenza vaccine appropriate for age and health status.[22] Recommendations for flu vaccination of persons with an egg allergy have not changed since the 2018–19 flu season. If a person only experiences hives after exposure to egg, they can receive any licensed flu vaccine. Persons who report having had more significant reactions to egg—such as angioedema, respiratory distress, lightheadedness or recurrent emesis—or who required epinephrine or another emergency medical intervention may similarly receive any licensed and recommended flu vaccine that is otherwise appropriate for the recipient's age and health status. The selected vaccine should be given in an inpatient or outpatient medical setting. The vaccine administration should be supervised by a healthcare provider who is able to recognize and manage severe allergic conditions. If a patient had a severe allergic reaction to a flu vaccine, regardless of the component suspected of being responsible for the reaction, is a contraindication to future receipt of the vaccine.[23] If a patient had a history of Guillain-Barré syndrome within 6 weeks after a previous dose of influenza vaccine, the vaccine should not be administered unless vaccination benefits outweigh risks for those at higher risk for severe complication from influenza.[24]

MEASLES, MUMPS AND RUBELLA

The measles, mumps and rubella (MMR) vaccine should be given to adults who are not up to date on their MMR vaccination.[25] Acceptable presumptive evidence of immunity against measles includes at least 1 of the following:

- Written documentation of adequate vaccination, including
  - 1 or more doses of a measles-containing vaccine administered on or after the first birthday for preschool-age children and adults not at high risk
  - 2 doses of measles-containing vaccine for school-age children and adults at high risk, including college students, healthcare personnel and international travelers
- Laboratory evidence of immunity
- Laboratory confirmation of measles
- Birth before 1957[26]

People born during or after 1957 who do not have evidence of immunity against measles should get at least 1 dose of the MMR vaccine. Healthcare personnel should have documented evidence of immunity against measles. People aged 6 months or older who will be traveling internationally should be protected against measles. Teenagers and adults born during or after 1957 without evidence of immunity against measles should have documentation of 2 doses of the MMR vaccine, with the second dose administered no earlier than 28 days after the first dose.[26]

Because MMR does not give 100% protection against mumps, public health authorities—a group at increased risk for acquiring mumps—should receive a third dose of MMR vaccine during a mumps epidemic. The purpose of the recommendation is to improve protection of people in outbreak settings against mumps disease and mumps-related complications.[27]

MENINGOCOCCAL DISEASE

The MenACWY vaccines and MenB vaccines can help prevent meningococcal disease, which is any type of illness caused by *Neisseria meningitidis* bacteria. There are 2 types of meningococcal vaccines available in the United States:

- Meningococcal conjugate or MenACWY vaccines (Menactra®, Menveo® and MenQuadfi®)
- Serogroup B meningococcal or MenB vaccines (Bexsero® and Trumenba®)

All 11- to 12-year-olds should get a MenACWY vaccine, with a booster dose at 16 years old. Teens and young adults (16–23 years old) also may get a MenB vaccine.[28] Both vaccines may be administered simultaneously if indicated but at a different anatomic site.[29] In certain situations, adults should receive MenACWY vaccines. Some people are at increased risk for serogroup A, C, W or Y meningococcal disease due to:

- Having certain medical conditions, such as
  - Complement component deficiency (eg, C5-C9, properdin, factor H, factor D)
  - Functional or anatomic asplenia (including sickle cell disease)
  - HIV
- Taking specific medications, such as a complement inhibitor (eg, Soliris® or Ultomiris®)
- Traveling or residing in countries in which serogroup A, C, W or Y meningococcal disease is common
- Working in specific professions or living in specific settings, including
  - Microbiologists who are routinely exposed to *Neisseria meningitidis*
  - Military recruits
  - First-year college students living in a residence hall and are not up to date with this vaccine
- Being a part of a community experiencing a serogroup A, C, W or Y meningococcal disease outbreak [30]

Phase 3 studies are being completed by GSK, combining MenACWY with MenB, so that the vaccines can be given as an injection.[31]

PNEUMOCOCCAL DISEASE

Pneumococcal vaccines now include the new pneumococcal conjugated vaccine 15 (PCV15)—VAXNEUVANCE™ by Merck—and the pneumococcal conjugated vaccine 20 (PCV20)—Prevnar by Pfizer. At age 65 years or older, those who have not previously received a pneumococcal conjugate vaccine or whose previous vaccination history is unknown should be given 1 dose of PCV15 or 1 dose of PCV20; if PCV15 is used, this should be followed by a dose of pneumococcal polysaccharide 23 valent (PPSV23) vaccine pneumovax by Merck. The dosing interval between PCV15 and PPSV23 should be at least 8 weeks to 12 months. For those aged 19–64 years with certain underlying medical conditions and who have not previously received a pneumococcal conjugate vaccine or those whose previous vaccination history is unknown, 1 dose of PCV15 or 1 dose of PCV20 should be given. If PCV15 is used, this should be followed by a dose of PPSV23 at least 8 weeks to 12 months apart.[32] Conditions that increase the risk of invasive pneumococcal disease include:

- Decreased immune function from disease or drugs
- Functional or anatomic asplenia
- Chronic heart, lung (including asthma), liver or renal disease
- Cigarette smoking
- Alcoholism
- Cerebrospinal fluid leak
- Cochlear implant[33]

VARICELLA VIRUS

Varicella (VAR) vaccination is recommended for all adults who have never had chickenpox or received the vaccination. Two doses of the vaccine should be given at least 4 weeks apart. On the other hand, because varicella is a live virus, the VAR vaccine should not be given to individuals who:

- Are moderately to severely ill at the time of vaccination
- Are pregnant (women should not become pregnant for 1 month after receiving the chickenpox vaccine)
- Have ever had an allergic reaction to gelatin, the antibiotic neomycin or a previous dose of chickenpox vaccine
- Are an organ donor recipient

People with the following conditions should be cautious and evaluated and receive shared clinical decision making with the healthcare provider and the patient before receiving the VAR vaccine:

- Patients undergoing chemotherapy or radiation for cancer
- People taking steroid drugs or other immunosuppressants
- People with HIV or another disease that compromises the immune system
- Patients who recently had a blood transfusion or received other blood products[34]

HERPES ZOSTER VIRUS

Recombinant zoster vaccine (RZV)—Shingrix by GSK—is the only herpes zoster vaccine available in the United States, now that Zostavax by Merck is no longer available. RZV is recommended to prevent shingles in adults aged 50 and older 35 as a 2-dose series, separated by 2–6 months.[35]

RZV is recommended for use in certain immunocompromised persons. Those conditions include but are not limited to:

- Hematopoietic stem cell transplant (HSCT) recipients
- Hematologic malignancies
- Renal or other solid organ transplants
- Solid tumor malignancies
- HIV
- Primary immunodeficiencies, autoimmune conditions and use of immunosuppressive medications/therapies[36]

Healthcare professionals should consider delaying RZV until after pregnancy. There is no recommendation for pregnancy testing before vaccination.[37]

CONCLUSIONS:

The slides from the November ACIP meeting when the 2022 immunization schedule was discussed can be accessed on the ACIP website.[38] A quick response bar code will be displayed on the cover page to afford easy access to immunization schedules,[39] along with an appendix to make it easier for clinicians and patients to detect contraindications and precautions for the commonly used vaccines. The revised 2022 immunization schedules were announced in the MMWR and posted on the CDC's vaccine website in late February 2022.

DISCLOSURES AND FUNDING: The author has disclosed the following: Speaker for Pfizer Men B vaccine; consultant for Pfizer PCV20; consultant for Dynavax for Hep B vaccine; consultant for Sequirus for Influenza vaccine; consultant for Takeda for Dengue vaccine.

REFERENCES:

1. Cover page draft of 2022 vaccine schedule, slide 53: https://www.cdc.gov/vaccines/acip/meetings/downloads/slides-2021-11-2-3/002-Immunization-Schedule-wodi-508.pdf
2. Centers for Disease Control and Prevention. 2021. Use of COVID-19 Vaccines in the United States. [online] Available at: https://www.cdc.gov/vaccines/covid-19/clinical- considerations/covid-19-vaccines-us.html#Coadministration
3. Centers for Disease Control and Prevention. 2021. CDC Vaccine Schedule app. [online] Available at: https://www.cdc.gov/vaccines/schedules/hcp/schedule-app.html
4. Centers for Disease Control and Prevention. Vaccine Adverse Event Reporting System (VAERS). Available at: https://www.cdc.gov/vaccinesafety/ensuringsafety/monitoring/vaers/access-VAERS-data.html
5. Centers for Disease Control and Prevention. 2021. COVID-19 ACIP Vaccine Recommendations. Available at: https://www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/covid-19.html
6. U.S. Food and Drug Administration. Comirnaty and Pfizer-BioNTech COVID-19 Vaccine. Available at: https://www.fda.gov/emergency-preparedness-and-response/coronavirus-disease-2019-covid-19/comirnaty-and-pfizer-biontech-covid-19-vaccine
7. U.S. Food and Drug Administration. COVID-19 Vaccines. Available at: https://www.fda.gov/emergency-preparedness-and-response/coronavirus-disease-2019-covid-19/covid-19-vaccines
8. Centers for Disease Control and Prevention. Johnson & Johnson's Janssen COVID-19 Vaccine: Overview and Safety. Available at: https://www.cdc.gov/coronavirus/2019-ncov/vaccines/different-vaccines/janssen.html
9. Centers for Disease Control and Prevention. Use of COVID-19 Vaccines in the United States. Available at: https://www.cdc.gov/vaccines/covid-19/clinical-considerations/covid-19-vaccines-us.html#Interchangeability
10. Centers for Disease Control and Prevention. COVID-19 Vaccine Boosters. Available at: https://www.cdc.gov/coronavirus/2019-ncov/vaccines/booster-shot.html?s_cid=11706:cdc%20covid%20booster%20dose:sem.ga:p:RG:GM:gen:PTN:FY22
11. Immunize.org. Ask the Experts: *Haemophilus influenzae* type b (Hib). Available at: https://www.immunize.org/askexperts/experts_hib.asp
12. Centers for Disease Control and Prevention. Hepatitis A Questions and Answers for Health Professionals. Available at: https://www.cdc.gov/hepatitis/hav/havfaq.htm
13. American Academy of Family Physicians. ACIP Recommends Hep A Vaccine for Homeless Patients. Available at: https://www.aafp.org/news/health-of-the-public/20181031acipmeeting.html
14. Centers for Disease Control and Prevention. Hepatitis B Questions and Answers for Health Professionals. Available at: https://www.cdc.gov/hepatitis/hbv/hbvfaq.htm
15. McMahon BJ. Meeting the WHO and US goals to eliminate Hepatitis B infection by 2030: Opportunities and challenges. *Clinical Liver Disease*. 2018;12:29–32. doi:10.1002/cld.733
16. Centers for Disease Control and Prevention. Hepatitis B Questions and Answers for Health Professionals: What are the recommended schedules for hepatitis B vaccination? Available at: https://www.cdc.gov/hepatitis/hbv/hbvfaq.htm#D4
17. PreHevbrio Hep B vaccine. Available at: https://www.prehevbrio.com/wp-content/uploads/2021/11/PreHevbrio-Full-Prescribing-Information.pdf
18. Rosselot GA. Last-Minute Travelers. Available at: https://wwwnc.cdc.gov/travel/yellowbook/2020/preparing-international-travelers/last-minute-travelers
19. Centers for Disease Control and Prevention. HPV Vaccination Recommendations. Available at: https://www.cdc.gov/vaccines/vpd/hpv/hcp/recommendations.html
20. Garland SM, Brotherton JML, Moscicki AB, *et al*. HPV vaccination of immunocompromised hosts. *Papillomavirus Res*. 2017;4:35–38. doi:10.1016/j.pvr.2017.06.002
21. Centers for Disease Control and Prevention. HPV Vaccine Information For Young Women. Available at: https://www.cdc.gov/std/hpv/stdfact-hpv-vaccine-young-women.htm
22. Grohskopf LA, Alyanak E, Ferdinands JM, *et al*. Prevention and control of seasonal influenza with vaccines: Recommendations of the Advisory Committee on Immunization Practices, United States, 2021–22 Influenza Season. MMWR Recomm Rep. 2021;70(No. RR-5):1–28. doi:10.15585/mmwr.rr7005a1

23. Centers for Disease Control and Prevention. Flu Vaccine and People with Egg Allergies. Available at: https://www.cdc.gov/flu/prevent/egg-allergies.htm
24. Centers for Disease Control and Prevention. Guillain-Barré syndrome and Flu Vaccine. Available at: https://www.cdc.gov/flu/prevent/guillainbarre.htm
25. Centers for Disease Control and Prevention. Measles, Mumps, and Rubella (MMR) Vaccination: What Everyone Should Know. Available at: https://www.cdc.gov/vaccines/vpd/mmr/public/index.html#:~:text=CDC%20recommends%20all%20children%20get,days%20after%20the%20first%20dose
26. Centers for Disease Control and Prevention. Measles (Rubeola): For Healthcare Providers. Available at: https://www.cdc.gov/measles/hcp/index.html
27. Centers for Disease Control and Prevention. Mumps: For Healthcare Providers. Available at: https://www.cdc.gov/mumps/hcp.html
28. Centers for Disease Control and Prevention. Vaccines and Preventable Diseases: Meningococcal Vaccination. Available at: https://www.cdc.gov/vaccines/vpd/mening/index.html#:~:text=CDC%20recommends%20routine%20MenACWY%20vaccination,increased%20risk%20for%20meningococcal%20disease
29. Centers for Disease Control and Prevention. Meningococcal Vaccination for Adolescents: Information for Healthcare Professionals. Available at: https://www.cdc.gov/vaccines/vpd/mening/hcp/adolescent-vaccine.html#:~:text=You%20can%20administer%20MenACWY%20and,different%20injection%20sites%20if%20feasible
30. Centers for Disease Control and Prevention. Meningococcal Vaccine Recommendations. Available at: https://www.cdc.gov/vaccines/vpd/mening/hcp/recommendations.html
31. GSK. (2020). GSK announces first participant vaccinated in phase 3 clinical trials of its 5-in-1, meningitis ABCWY vaccine candidate. Available at: https://www.gsk.com/en-gb/media/press-releases/gsk-announces-first-participant-vaccinated-in-phase-3-clinical-trials-of-its-5-in-1-meningitis-abcwy-vaccine-candidate/
32. Park B. 2021. ACIP Recommends Updates to Pneumococcal Vaccination Guidelines. Available at: https://www.empr.com/home/news/acip-recommends-updates-to-pneumococcal-vaccination-guidelines/
33. Centers for Disease Control and Prevention. Pneumococcal Disease: Risk Factors. Available at: https://www.cdc.gov/pneumococcal/clinicians/risk-factors.html
34. Byrd F. Chickenpox (Varicella) Vaccine for Adults. *WebMD*. Available at: https://www.webmd.com/children/vaccines/chickenpox-varicella-vaccine-guidelines-for-adults
35. Centers for Disease Control and Prevention. Shingles (Herpes Zoster): Vaccination. Available at: https://www.cdc.gov/shingles/vaccination.html#:~:text=Recombinant%20zoster%20vaccine%20(RZV%2C%20Shingrix,within%202%20to%204%20weeks
36. Centers for Disease Control and Prevention. Administering Shingrix. Available at: www.cdc.gov/vaccines/vpd/shingles/hcp/shingrix/administering-vaccine.html
37. Anderson TC, Masters NB, Guo A, *et al*. Use of recombinant zoster vaccine in immunocompromised adults aged ≥19 years: Recommendations of the Advisory Committee on Immunization Practices — United States, 2022. MMWR Morb Mortal Wkly Rep 2022;71:80–84. doi:10.15585/mmwr.mm7103a2
38. ACIP. November 2022 Vaccine Immunization discussion. Available at: https://www.cdc.gov/vaccines/acip/meetings/downloads/slides-2021-11-2-3/002-Immunization-Schedule-wodi-508.pdf
39. American Academy of Family Physicians. 2022 Immunization Schedules Updated at November ACIP Meeting. Available at: https://www.aafp.org/news/health-of-the-public/20211118acip.html

REVIEW ARTICLE

LOW-BACK PAIN IN ADOLESCENTS WITH AN OSTEOPATHIC COMPONENT

Puneet Tung, DO, FAAP

[1]Penn State College of Medicine, Hershey, PA

KEYWORDS:

Adolescent

Low-back pain

Osteopathic manipulative medicine

Abstract

Low-back pain (LBP) is a common symptom presenting in adolescents. Most back pain in adolescents is benign and musculoskeletal in nature, due to trauma or congenital anomalies. Other less common causes include infection, inflammatory conditions or neoplasm. A comprehensive history and physical focusing on posture, muscle tenderness, range of motion, muscle strength and neurological function is essential in understanding the cause of low-back pain. Identification of risk factors for low-back pain will help the clinician in managing their patient. Treatment includes rest, avoiding activities that cause pain, physical therapy, osteopathic manipulative treatment, limited use of non-steroidal anti-inflammatory drugs and family and patient education. Assessing for warning signs or red flags of serious causes of LBP is a fundamental part of the clinical assessment. Pain that awakens from sleep, pain lasting longer than 4 weeks, sudden onset pain, systemic findings such as fever or weight loss and abnormal neurological findings should warrant immediate evaluation as these may suggest serious infectious conditions, malignancy or fracture. This article presents a comprehensive review of the epidemiology, relevant anatomy, biomechanics, causes and major risk factors for adolescent low-back pain. A diagnostic algorithm utilizing a step-by-step approach is also introduced to aid the clinician in management of the patient. Finally, the article presents guidelines for management of the adolescent with low-back pain including conservative, pharmacologic, as well as the osteopathic approach to treatment. Evidence-based recommendations on osteopathic approach to treatment has been reviewed from meta-analysis data and randomized controlled trials.

INTRODUCTION AND EPIDEMIOLOGY

Low-back pain (LBP) is a common complaint among children and adolescents. Most back pain in children and adolescents is benign in nature and caused by musculoskeletal conditions or trauma. Some adolescents have serious underlying congenital causes for LBP or acquired causes. Adolescent low-back pain has been as reported in the literature as common as the adult population.[1–3] Commonly, transient LBP presents in children and then into early adolescence.[4–6] It has been found that the risk for LBP increases with increasing age, pubertal development and linear growth.[7,8] A study within the Danish National Birth Cohort explored the differential nature of LBP and 7% of 12-year-olds had at least one episode of LBP.[8] The lifetime prevalence of LBP, by age 20, has been reported as high as 80%.[1] Prevalence increases with age, reaching a peak at the 6th decade of life. Based on the results of several large prospective trials, the best predictor of LBP is a previous history of LBP.[9]

CORRESPONDENCE:
Puneet Tung, DO, FAAP | ptung@pennstatehealth.psu.edu

 Print ISSN: 1877-573X
doi:10.33181/13078

The prevalence of LBP in children and adolescents vary from 17%–26% based on several studies and is dependent on the age of a child and, in particular, the definition of LBP.[10–13] Similarly in adults, the prevalence of LBP is more common in females and increases with age.[14] There is a U-shaped relationship between physical activity and the prevalence of LBP in children. Low levels and high levels of physical activity contribute to a higher risk of LBP.[15,16] The etiology of LBP ranges from a sedentary lifestyle, prolonged screen time, sports injuries, psychosocial issues and a positive family history of LBP.[16-18] LBP may substantially restrict activities of daily living, in the adolescent population, such as school, sports or social activities. This paper presents an osteopathic approach to the diagnosis and treatment of adolescent LBP in the primary care setting with a focus on causes of LBP, biomechanics and relevant anatomy, risk factors, diagnostic strategies and treatment. A summary of evidenced based studies from the PubMed database of biomedical literature is reviewed and discussed. Search criteria were limited to studies in English and humans and key words were "adolescents" (aged 10–19), and "low-back pain". This summary also reviews the effectiveness of osteopathic manipulative treatment (OMT) and other treatments in the management of the adolescent with LBP.

CAUSES OF LOW-BACK PAIN

The differential diagnosis of LBP in adolescents is broader and more diverse than that seen in the adult population. In most children and adolescents with LBP, the etiology is benign, musculoskeletal in nature or due to trauma. Other, but less common causes, include infection, inflammatory conditions or neoplasm (Table 1).[17,19-23] In a large published series, of children and adolescents aged 10–19, 80% of adolescents had no identifiable diagnosis with their chief complaint of LBP. The most common diagnoses were lumbar strain/spasm (8.9%), scoliosis (4.7%), degenerative disk disease of lumbar area (1.7%) and lumbar disk herniation (1.3%). Less than 1% of complaints due to LBP were due to spondylolysis, spondylolisthesis, infection, neoplasm or fracture.[19]

Back pain is an uncommon complaint in the pediatric emergency department (ED) setting. A study at an urban pediatric ED looked at the chief complaint of back pain over the course of one year and found that only 0.4% of ED visits accounted for LBP. Of the children who complained of LBP, 90% had pain fewer than 4 weeks and the most common diagnoses were direct trauma (25%), musculoskeletal strain (24%), sickle cell crisis (13%), idiopathic (13%) and infections such as a urinary tract infection or viral infection (9%). Imaging was rarely helpful in this setting.20 Reassuringly, LBP resolves in children. In several longitudinal cohorts, only 7% of the entire studied population reported persistent pain at follow up assessments and most pain was non-specific and self-limiting.[5,21,22]

Nonspecific musculoskeletal pain and muscle strain appear to the most common causes of LBP in adolescents and account for nearly 50% of cases depending on the study population.[8,19,22–25] These patients usually do not present with any warning signs to suggest other pathology. The most common factors associated with non-specific LBP include older age and sports participation,[6,20] soft mattress usage,[26] sports equipment such as poorly cushioned running shoes or improper bicycle seat position,[27] increased thoracic kyphosis[28] and underlying mental health issues and psychosocial stressors.[29,30] A large systematic review looked at whether LBP was associated with heavy shoulder backpack usage and there was no correlation.[31] Muscle strain is usually related to overuse or overstrain and worsened by twisting or lifting. Other common and less common causes of LBP in adolescents are described in more detail in Table 1.

TABLE 1:

Differential diagnosis of low-back pain in adolescents

CONDITION	TYPICAL AGE GROUP	RISK FACTORS	HISTORY AND PHYSICAL EXAM FINDINGS	DIAGNOSTIC TOOLS
Non-specific musculoskeletal pain and muscle strain				
Non-specific musculoskeletal pain	All ages	Older age group Sports participation Co-morbid medical conditions Psychosocial stressors Sleep environment	Warning signs or red flags are usually absent	History and physical
Muscle pain	All ages	Inciting activity Trauma Overuse injury	Pain with activity Pain with lifting or twisting Muscle tenderness but no radiation Pain relieved with rest	History and physical
Thoracic pain				
Scheuermann Kyphosis	Early adolescence	Tall stature Boys > girls	Sharp angulation when bending over Pain with flexion, activity and at the end of the day	AP and lateral spine radiographs
Thoracic or lumbar pain				
Scoliosis	Adolescents	Idiopathic or congenital spinal anomalies	Lateral curvature of the spine with ADAMS test	Forward bend test Scoliometer Cobb angle more than 10o Standing PA or lateral views of the spine
Osteoid osteoma	Adolescents	Second decade of life	Nocturnal pain Relieved by NSAIDs Can be associated with scoliosis	CT

TABLE 1 CONT'D:

Malignancy - Primary tumor (Ewing sarcoma, osteochondroma) - Secondary malignancy leukemia, lymphoma, neuroblastoma, metastatic disease	Any age	May have a history of malignancy	Fever, weight loss, malaise, nocturnal pain, abnormal neurological findings, bowel or bladdery dysfunction	Blood work (CRP, ESR, CBC), CT scan
Spinal epidural abscess	Any age	Untreated can go from LBP to root pain ("shooting pains" to neurological deficits)	Fever, spinal pain, neurological deficits	Blood work (CRP, ESR, CBC) MRI
Vertebral osteomyelitis (including TB spondylitis, Pott disease)	Adolescents	History of infection	History of infection Systemic symptoms, constant pain, localized pain with percussion, ill appearing, nocturnal pain, exposure to TB limping	Blood work (CRP, ESR, CBC), blood culture, bone scan, MRI
Vasoocclusive crisis	All ages	History of sickle cell disease	Severe pain	Abnormal UA (concentrated, hematuria, proteinuria)
Tethered cord	All ages	Recent onset of scoliosis with severe pain	Younger children: refusal to do certain activities Older children: back pain exacerbated by exercise Neurological findings	MRI
Syringomyelia	All ages	Can be associated with congenital anomalies (eg, Arnold-Chiari malformation type 1), spinal infection, inflammation, malignancy	Clinical presentation is variable Recent onset scoliosis with severe pain Progressive central spinal cord deficits	MRI
Transverse myelitis	All ages	Associated with infection or systemic autoimmune disorder (eg, Lupus, ankylosing spondylitis)	Abnormal motor, sensory and/or autonomic findings	MRI
Chronic nonbacterial osteomyelitis	Between ages 7 and 12 years	Can affect the thoracic or lumbar spine Can be associated with psoriasis, palmoplantar pustulosis, acne, inflammatory bowel disease and spondyloarthropathy	Low grade fever, localized low back pain	Blood work (CRP, ESR, CBC), blood and bone cultures are usually negative
Lumbar or lumbosacral pain				
Hyperlordodic back pain	Any age	Weak core	Weak core muscles Increased lumbar lordosis	Clinical examination, imaging negative, Positive Trendelenburg sign, increased lumbar lordosis with thoracic kyphosis
Lumbosacral transitional vertebra (Bertolotti syndrome)	All ages	None	Nonspecific LBP Poorly localized unilateral LBP Insidious onset Increased lumbar lordosis	Physical exam Radiographs will demonstrate sacralization of last lumbar vertebrae CT scan

TABLE 1 CONT'D:

Intervertebral disc disease and herniated nucleus pulposus	Adolescents	Uncommon cause of LBP Acute trauma and axial load Scheuermann kyphosis Family history Obesity/overweight Associated with weightlifting, gymnastics, wrestling and collision sports	Pain radiating to buttocks or lower extremities Pain worse with flexion Limited Spinal flexibility Positive SLR test Leg pain is worse than back pain Severe herniation can lead to cauda equina syndrome	MRI
Spondylolysis	Early adolescence	More common in boys than girls Associated with: Scheuermann kyphosis, repetitive trauma	Pain extending into buttocks and thighs Pain worse with extension, improved with rest Hamstring tightness Positive SLR	Physical exam Radiographs CT scan
Spondylolisthesis	Early adolescence	More common in boys than girls Associated with Scheuermann kyphosis, certain sports and repetitive trauma	Pain extends into buttocks and posterior thighs Pain with extension Hamstring tightness Prominent spinous process Flattening of the normal lumbar lordosis Knee-flexed, hip-flexed gait	Physical exam Radiographs CT scan
Apophyseal ring fracture	Adolescents	Boys more than girls Associated with activities that require lumbar hyperflexion Associated also with Scheuermann kyphosis, and intervertebral disc herniation Associated with weightlifting, wrestling and gymnastics	Pain radiating to buttocks or lower extremities Pain worse with flexion Positive SLR test Leg pain is worse than back pain	Radiographs CT scan
Inflammatory arthritis: - Ankylosing spondylitis - Psoriatic arthritis - Arthritis of inflammatory bowel disease - Reactive arthritis	All ages	Family history of inflammatory spondylitis	Nocturnal pain Morning stiffness Chronic pain SI joint tenderness (positive FABER test) Flattening of the lumbar curve on flexion Involvement of other joints	HLA-B27 although not specific Plain radiographs MRI detects early disease

TABLE 1 CONT'D:

Discitis	Younger children	Rare case of LBP Low grade infection on spectrum of vertebral osteomyelitis Due to mild presentation may be underdiagnosed	Nocturnal pain Generally, affects lower lumbar spine Gradual onset of irritability and LBP, lip or refusal to bear weight No systemic toxicity Fever is absent or low-grade Examination findings: refusal in flexion, percussion tenderness over involved spine, hip pain, stiffness, loss of lumbar lordosis	Blood cultures are sterile ESR MRI Antibiotics
Paraspinal muscle pain				
Pyomyositis	Young children Young adults	Predisposing factors include immunodeficiency, trauma, injection drug use, concurrent infection and malnutrition	Fever and muscle tenderness localized to a single muscle group More common in the tropics, but has been reported in temperate climates	Blood work (CRP, ESR, CBC) CT
Viral myalgia	All ages	Prodrome or early phase of acute viral infections	Preceding viral illness (eg, rhinitis, pharyngitis, cough) LBP common	History and physical
Referred back pain				
Pain amplification/ chronic pain syndromes	Adolescents	Family history Pain at multiple sites	Chronic pain Discordance between reported symptoms and physical exam findings Repeated school absences	Lab work and imaging findings are not useful
Pyelonephritis	All ages	Ascending UTI	Dysuria Fever Abnormal UA	History and physical UA
Pneumonia	All ages	Younger age Prematurity Underlying pulmonary or cardiac disease	Fever Cough Tachypnea Abnormal pulmonary exam	History and physical CXR
Pelvic inflammatory disease	Sexually active adolescent females	Multiple sexual partners Unprotected sex	Fever Abdominal pain/pelvic pain	History and physical STI labs
Pancreatitis	All ages	Associated with trauma, infection, structural anomalies, some medications	Fever Acute, consistent mid to upper abdominal pain that radiates to the back Nausea and vomiting	History and physical Labs (CRP, ESR, CBC, amylase, lipase) Imaging
Nephrolithiasis	All ages	Diet Obesity Certain medical conditions	Severe back pain	Abnormal UA

BIOMECHANICS AND RELEVANT ANATOMY

In order to understand the etiology of LBP, clinicians need a complete understanding of the biomechanics and relevant anatomy of the spine, intervertebral discs and surrounding soft tissues. LBP is usually localized to the lower thoracic, lumbar or lumbosacral spine. The primary function of the spine is to protect the spinal cord and the nerve roots, while also allowing for full range of motion and to support and balance the entire body. The axial spine has 3 planes of motion: flexion and extension, lateral flexion and lateral rotation.[23] The thoracic spine consists of 12 vertebrae (T1–T12) and lumbar spine consists of 5 vertebrae (L1–L5). The sacrum (S1–S5) is a fused bone at the base of the spine and articulates with the ilium, and the upper part connects with L5 and its lower part connects with the coccyx. The sacral plexus is derived from the anterior rami of spinal nerves: L4, L5, S1, S2, S3 and S4. Subsequently, each of these anterior rami supply the anterior and posterior branches. The anterior branches innervate the flexor muscles of the lower extremity and the posterior branches innervate the extensor and abductor muscles of the lower extremity. The sacroiliac (SI) joint has numerous ridges and depressions, and its function is more for stability than movement. There is an intervertebral disc between each thoracic and lumbar vertebra. Between L5 and the sacrum there consists of a diarthrodial joint with limited range of motion. The spinal nerves exit posteriorly and bilaterally from the foramina of the thoracic and lumbar vertebral body. The complex anatomy of the lumbar region also consists of flexible ligaments, tendons and large muscles.

RISK FACTORS

Recognizing risk factors is important when assessing an adolescent with LBP. During the history, the clinician should ask questions regarding family history of low-back pain, any significant past medical history, time spent being sedentary, posture when doing schoolwork or using a computer and their physical activity level as well as the hours, type and intensity of this activity.[32–34] A physical exam should always obtain a height and a weight to determine BMI. A large cohort study did a survey of LBP in 13- to 16-year-old adolescents regarding their sedentary activities, sports participation, employment and smoking. The risk for developing LBP appears to be multi-factorial such as female gender, BMI > 25kg/m2, tightness of hamstring muscles, hypermobility, competitive sports participation, daily smoking, prolonged sedentary activities such as screen time, jobs that require heavy lifting as well as social and psychological factors.[34] The risk of LBP also increases with age.[21,33,34] A larger, more recent systematic review suggested that the association between LBP and risk factors were inconsistent but did note that older age and participation in competitive sports demonstrated a consistent association with LBP.[21] It does appear that more studies are needed to fully determine the prevalent risk factors of LBP in adolescents.

OSTEOPATHIC STRUCTURAL EXAM/ CLINICAL APPROACH

The osteopathic philosophy to patient care is characterized by a holistic and whole-body approach. It places an emphasis on the relationship and connection between physiological and anatomic structures. This approach also emphasizes the psychosocial and environmental influences that can cause pain. Previously, there used to be a paucity of medical literature on the effectiveness of osteopathic manipulative medicine for low-back pain, but growing evidence suggests that isolated manual techniques and patient education can improve lower back pain.[35–36]

Similar to other medical complaints, a complete and accurate history and comprehensive physical examination are key to proper diagnosis and management of LBP. The provider should ask the adolescent and their parent regarding the onset of pain, location of symptoms, duration of symptoms, description of the pain characteristics, presence or lack of radiation, aggravating or alleviating factors as well as any other associated symptoms. Acute onset pain is usually caused by trauma, while pain that is slower to present is usually caused by muscular, inflammatory, bony or biomechanical issues. Clinicians should also ask about the adolescent's participation in sports and other activities to see how much their pain is limiting their participation. In order to elucidate whether the adolescent is having inflammatory pain or mechanical pain, the provider should ask if they have morning stiffness or reduction of pain with movement or activity. Inflammatory pain decreases with physical activity and increases with prolonged rest. Mechanical pain increases with physical activity. In addition, family history is important, in particular to reveal any neurological or rheumatologic conditions or congenital anomalies.[37]

There are several well validated pain scales used in children to rate pain and severity. The visual analog scale (VAS) is a method that quantifies pain severity. It is a continuous outcome measure and has a 100 mm scale from 0–100 with 0 being the low end of pain and 100 being the high end of pain. This is easy to administer and has been studied in older children and adults.[38] The Wong-Baker FACES Pain Scale is a tool that uses facial expression drawings to describe the severity of pain and been extensively studied in children. Additionally, it is a well validated scale for chronic pain. Its reliability and validity have been confirmed in children and adolescents aged 3–18. Strong correlations have been reported between the Wong-Baker scores and VAS.[39–40]

A focused musculoskeletal exam and neurological exam should be performed on all children and adolescents with a particular focus on deep tendon reflexes, muscle strength and sensation in the lower extremities. This will elucidate any underlying neurological or intraspinal pathologies that would require an urgent specialist evaluation and/or imaging. A neurological assessment should include lower extremity sensation, motor strength and reflexes of the patellar tendon (L4) and Achilles tendon (S1). Dermatome sensation of T12 and S1 as well as muscle function of the hip flexors (L2, L3) and quadriceps (L3, L4) and extensor hallucis longus (L5) should be examined. The musculoskeletal exam should focus on core strength and stability and will evaluate if there are not only weaknesses in the abdominal musculature, but also the paraspinal

musculature. The adolescent should be examined in all planes of motion while also sitting, standing or walking. Full range of motion exercises, such as lumbar lateral rotation, lateral bending, flexion and extension, should also be performed. Leg length discrepancy and scoliosis may present with spinal misalignment, scapular asymmetry or pelvic obliquity. Scheuermann kyphosis will present with a kyphotic deformity. The clinician should palpate the entire spine and back musculature to evaluate if there is any tenderness over any spinous processes, musculature or SI joint. There are also several major clinical examination tests that should be performed (Table 2) that may aid the clinician in diagnosis.

Assessing for warning signs or red flags of serious causes of LBP is a fundamental part of the clinical assessment. The purpose is to evaluate for any serious pathology that would cause LBP and warrant referral for urgent medical management. This would include pain that awakens from sleep, abnormal neurological findings, such as asymmetric reflexes, saddle paresthesia, muscle weakness, extensor plantar response, low rectal tone and bladder or bowel dysfunction, and are listed in Table 3. Suspicion for underlying infectious conditions, malignancy or fracture should be evaluated if the clinician notes any systemic signs, including fever, fatigue, weight loss, loss of appetite, or localized tenderness on the spine.[17,32,33,37] Neurological symptoms such as radiculopathy and loss of bowel or bladder function are concerning, and it is essential for the clinician to rule out intervertebral disk herniation or cauda equina syndrome. Morning stiffness may be due to inflammatory arthropathies. Physicians should also ask about family history of autoimmune diseases, malignancy and scoliosis. The consistent use of a diagnostic algorithm when evaluating an adolescent with LBP will ensure that concerning etiologies of pain are completely evaluated. Figure 1 describes an algorithm that can help the clinician work through process of evaluating an adolescent with LBP.[41,42]

There is also a strong link between psychosocial issues and LBP.[4,29] Factors like poor mental health, difficulties with peers, bullying, anger, attention and concentration deficits, having a parent with LBP, fatigue and other sources of pain can contribute to this complaint.[29,30] Involving the family and working with the whole family system to support the adolescent understand their pain is an important tool. Referral to a family counselor, pediatric psychologist or therapist or pediatric psychiatrist may be needed to address underlying mental health issues. Working through an algorithm can help reveal any positive psychosocial stressors, but also understand if there is a physiological source of their LBP as well.

If the clinician has a high suspicion for inflammatory, autoimmune, infectious or malignant process, laboratory work, such as a complete blood count and inflammatory markers (CRP, ESR) would be necessary. If concerned about an autoimmune process, consulting a rheumatologist prior to ordering labs would be important, because nearly 20% of the general population has a positive antinuclear antibody.[43] Imaging should be obtained in adolescents who have had LBP longer than 3 weeks and, ideally, anterior posterior and lateral X-rays should be considered. If initial radiography is inconclusive, advanced imaging may be pursued. Computed tomography (CT) can provide details on the bones and cartilage but does expose the growing adolescent to high doses of radiation and should be ordered with caution. Magnetic resonance imaging (MRI) can be used for suspicion of bone pathology, as well as soft tissue pathology.

TABLE 2:
Low-back pain examination maneuvers

CLINICAL TEST	DESCRIPTION	DIAGNOSIS
Adams forward bending test	Keeping feet together and knees straight, adolescent should bend forward. Positive test: asymmetry in rib cage or curvature of spinal column	Positive test suggests scoliosis
Straight leg raise	Supine position, adolescent's leg should be raised when knees are straight. Positive test: pain felt by patient when 30–70 degrees of hip flexion and radiates into the posterior thigh and knee	Sciatic pain suggests herniated nucleus pulposus If hamstrings are tight, pain is localized to the hamstring area.
Flexion, abduction, external rotation	Supine position, knee is flexed to 90 degrees, hip is abducted and externally rotated. The pelvis should be held and fixed by the opposite hand. Positive test: pain felt in buttock, groin or sacroiliac joint	Positive test suggests pathological condition of the SI joint or intraarticular hip pathology.
Trendelenburg	Standing on one leg check the position of the pelvis. Positive test: pelvis of the other side drops	Positive test indicates issues of the lower extremity and gluteal and hip abductor weakness, decreased core strength or a neurological deficit
One-legged hyperextension test	While standing on one leg and bending backward, pain is experienced in the ipsilateral back	Positive test suggests spondylolysis

TABLE 3:
Red flags for low-back pain

History	• History of acute or repetitive trauma • Pain that radiates down buttocks • Pain that is severe, nocturnal, at rest or progressive • History of malignancy • History of exposure to tuberculosis • Morning stiffness
Physical examination	• Abnormal neurological findings (eg, asymmetric reflexes, weakness, extensor plantar response, low rectal tone, bladder or bowel dysfunction, saddle paresthesia) • Fever with or without systemic findings • Weight loss

MANAGEMENT

The specific treatment for LBP varies widely depending on the etiology of the pain. Most adolescents present with non-specific LBP and will respond to conventional treatment including rest, avoiding any activities that exacerbate their pain and physical therapy.[44,45] There is a paucity of medical literature on randomized controlled trials that focus on conservative options for LBP in adolescents. From a recent meta-analysis and systemic review, it suggests that a supervised exercise program is more effective at reducing LBP compared to no program at all.[44] However, exercise alone will not alleviate all LBP. It appears that to focus on the multiple risk factors for LBP, including social, physical, psychological and lifestyle, that a multidisciplinary approach may be more effective.

In addition, there have been several rehabilitation programs with a focus on alleviating LBP, but little literature on supporting these programs. LBP rehabilitation programs must be individualized to address the various patient populations. The rehabilitation may include exercise and physical therapy to manipulation and bracing.[46] A recent systemic review evaluated the approaches to LBP rehabilitation and concluded that treatment should be multifactorial.[47] No single exercise program is right for each patient, but should focus on muscular strength, flexibility and/or aerobic fitness. Improving core muscle strength can support the lumbar spine, increasing the flexibility of the muscles, tendons and ligaments of the lower back can increase the range of motion of that area and improve movement. Additionally, aerobic exercise enhances the flow of blood and nutrients to the lower back and will aid in the healing process. Cognitive functional therapy has been studied as part of a multidisciplinary and multidimensional approach to adolescent LBP.[43] The literature reflects an evolving emphasis on a biophysical approach to the diagnosis and treatment of LBP. Adolescents are motivated to learn about the non-physical factors that may contribute to their pain. Counseling may improve their general health.[29,30,45]

Improving adolescent LBP relies on treating the acute injury, recognizing any problems in biomechanical function and changing the behavior or technique that may promote injury. Rehabilitation evolves through steps that focus on improving and encouraging range of motion and strength and reducing injury.[45] Emphasizing exercises that strengthen the hip flexors and hamstrings can increase hip flexibility. Core stabilization improves the strength, endurance, flexibility and neuromuscular control of the muscle groups that provide spine and trunk stability.[48] Therapy for specific diagnoses, such as spondylolysis, may involve a flexion-based therapy program, if there is pain with back extension, compared to conditions such as a herniated disc, which is treated with an extension-based therapy program because of pain with flexion.[49] The overall goal is a progression to activity specific exercises that allows an adolescent a gradual and pain-free return to their specific sport or activity.

Thoracic and lumbar bracing are also used in the management in the adolescent with LBP. Bracing includes soft lumbar corsets and rigid braces.[50] However, there is little evidence to support that bracing is more effective to conservative treatment alone. Some clinicians will use rigid bracing to further restrict activity that will exacerbate pain. Current medical evidence suggests against rigid bracing in spondylolysis and most have an excellent outcome with conservative treatment.[19,37]

To date, there are no randomized controlled trials comparing the use of analgesics such as non-steroidal anti-inflammatory drugs (NSAIDs) and acetaminophen in the treatment and management of LBP in adolescents. A Cochrane review looked at the efficacy of NSAIDs in those aged 16 and older with LBP, and NSAIDs seemed slightly more effective than placebo for short-term pain reduction and disability.[51] If a patient's LBP is unresponsive to conservative therapy or has persisted past four weeks a referral to a specialist may be warranted. A surgical approach may be needed for herniated nucleus pulposus, discogenic pain, apophyseal ring fracture and spondylolysis.[52]

OSTEOPATHIC APPROACH TO LOW-BACK PAIN

Osteopathic manipulative medicine (OMM) is a treatment modality used to diagnose and treat patients with somatic dysfunction. Somatic dysfunction is defined as altered and impaired function of the parts of the somatic system including the skeletal, joints and muscular structures as well as their neural, lymphatic and vascular properties. There are four major principles or tenets of osteopathic medicine:

- The body functions as a unit of body, mind and spirit

- The body is able and capable of self-healing, self-regulation and health maintenance

- Structure and function are interrelated

- Rational treatment is based upon an understanding of the basic principles of body unity, self-regulation and the interrelationship of structure and function.

Osteopathic manipulative treatment (OMT) is an effective and safe approach used by osteopathic physicians to complement conventional management of LBP. OMT can be used to diagnose and treat LBP and has been shown to decrease pain and improve musculoskeletal function and movement. LBP is one of the most

frequently treated conditions with OMT.[53,54] There are several systematic reviews and meta-analysis that demonstrate that OMT is more effective than control measures in pain reduction and functional status for adult patients with acute and chronic LBP.[53, 55–57] These results suggest that the positive benefits of OMT may have the potential to last beyond one year.

The American Academy of Pediatrics recommends that clinicians understand that there are many pediatric conditions that would benefit from a complementary health approach.[58] OMT is one of the most frequently used complementary health treatments for pediatric patients with neck and back pain.[59] In a review of outpatient pediatric clinical encounters at a neuromuscular medicine/OMM clinic, the most common age group were early adolescents. The primary presenting complaint, in the early and late adolescence age group, was back pain. In the same age group, the most common clinical assessment was LBP or lumbar strain/sprain.[58] OMT in children appears to be a safe treatment modality when done by physicians with training and expertise in OMM.[54,58,60,61]

Techniques used in pediatric OMT include counterstrain (CS), myofascial release (MFR), muscle energy, high velocity/low amplitude (HVLA), and lymphatic pump and are described in Table 4.[54,60–62] A comprehensive history and physical and using a standard algorithm will help the clinician discern the patient's diagnosis. The overall goal of OMT is to remove the obstruction and restore normal motion and function. OMT is classified by indirect or direct techniques. HVLA and muscle energy requires the clinician to move the region of restriction through a barrier and indirect techniques, such as CS, are directed opposite the restricted barrier. MFR can be either direct, indirect or both. In determining which technique to use, the clinician should take the patient's age, level of cooperation and ability to follow directions into consideration.

Student athletes involved in throwing or kicking sports are at a higher risk of SI injury.[62] Common techniques for SI dysfunction include HVLA and muscle energy.[54] Patients may complain of pain up to 48 hours post-treatment, but the pain usually self-resolves.[54,62] OMT may decrease unnecessary imaging, medications, referrals and invasive interventions. In addition, a more holistic approach to diagnosis and management may help the provider understand any risk factors that may exacerbate LBP. Contraindications to OMT include acute sprain or strains, fractures or dislocations, joint instability, malignancy or infection. Larger and more robust randomized controlled trials are needed in children and adolescents to determine and validate the effects of OMT on acute and chronic LBP. OMT and exercise have been shown to be effective in the adult populations, high quality research is needed to understand their effectiveness in the adolescent population with LBP. An ideal study would be a double-blind randomized controlled trial to address the intervention of OMT in adolescent LBP.

TABLE 4:
Osteopathic manipulative techniques

OSTEOPATHIC MANIPULATIVE TECHNIQUE	DESCRIPTION
Counter-strain	Gentle indirect treatment. Place patient in a position of mild strain in the direction opposite the barrier. Involves a tender point and patient is positioned to maximum comfort until pain is reduced by 70%.
Myofascial release/ soft tissue technique	Areas of dysfunction are revealed with soft tissue palpation and technique involves soft tissues versus skeletal or arthrodial structures. Treatment involves lateral and linear stretching, deep massage, traction and muscle stretch or compression. The goal is to restore motion and functionality with tissue relaxation.
Muscle energy	Direct patient muscular contraction away from a restrictive barrier against resistance from the clinician. Used in treating motion restriction.
High velocity/low amplitude	Using a thrust or impulse there is direct engagement of a motion barrier. Goal is to improve joint motion.
Lymphatic pump	Gentle and rhythmic technique that improves function through improved fluid drainage. Goal is to improve lymphatic movement.

PREVENTION

The skeletally immature adolescent goes through periods of rapid growth. They are more vulnerable to muscle contractions and trauma so focusing on education and prevention of injuries is important.[63] Evolving evidence suggests that programs that focus on a pre-season conditioning program that starts several weeks before the start of a sport season allows for a gradual increase in activity level. The program should aim to increase flexibility, endurance and neuromuscular training which has been shown to reduce injury rates.[61,62] Also, the adolescent should be allowed to rest and recover after a low-back injury especially with activities that require repetitive movements. In general, if the clinician follows an evidence-based advice strategy, young athletes should not participate in more hours of sports per week older than their age in years, which will help reduce overuse injuries and most back injuries.[63,64]

CONCLUSION

LBP in adolescents is a diagnosis that is most often self-limited, musculoskeletal or non-specific in nature and responds to simple conservative treatments. The clinician should perform a comprehensive history and physical and by using an algorithm should be able to distinguish between benign and serious causes of LBP. In addition, the clinician should be vigilant and understand the warning signs of serious causes of low-back pain and respond promptly and provide the appropriate referrals, imaging and lab work. The role of psychosocial factors as an etiology of LBP in adolescents should also not be undervalued and involving the appropriate mental health specialists may be necessary. Physical therapy can be helpful with core-strengthening exercises and increasing lower extremity flexibility. In addition, patient education on preventative measures such as postural awareness, improving and increasing core strength, increasing core flexibility, relaxation and stress management and age-appropriate sports participation should help reduce future LBP injury. Finally, there is more mainstream acceptance of the efficacy of OMT in treating LBP. Several studies have demonstrated safety and efficacy of OMT in the adult and pediatric population. OMT should be considered a treatment modality in adolescents with LBP as it is safe, low-cost, non-invasive, effective and practical.

DISCLOSURES AND FUNDING: The author received no financial support related to this submission and have no financial affiliations or conflict of interest related to this article to disclose.

REFERENCES:

1. Jones G, Macfarlane G. Epidemiology of low-back pain in children and adolescents. *Archives of Disease in Childhood*. 2005;90(3):312–316. doi:10.1136/adc.2004.056812
2. Burton A, Clarke R, McClune T, *et al*. The natural history of low back pain in adolescents. *Spine*. 1996;21(20):2323–2328. doi:10.1097/00007632-199610150-00004
3. Harreby M, Neergaard K, Hesselsôe G, Kjer J. Are radiologic changes in the thoracic and lumbar spine of adolescents risk factors for low back pain in adults? *Spine*. 1995;20(21):2298–2302. doi:10.1097/00007632-199511000-00007
4. Masiero S, Carraro E, Celia A, *et al*. Prevalence of nonspecific low-back pain in schoolchildren aged between 13 and 15 years. *Acta Paediatr*. 2008;97(2):212–216. doi:10.1111/j.1651-2227.2007.00603.x
5. Jones GT, Macfarlane GJ. Predicting persistent low-back pain in schoolchildren: a prospective cohort study. *Arthritis Rheum*. 2009;61:1359–1366. doi:10.1002/art.24696
6. Calvo-Muñoz I, Gómez-Conesa A, Sánchez-Meca J. Prevalence of low-back pain in children and adolescents: a meta-analysis. *BMC Pediatr*. 2013;13:14. doi:10.1186/1471-2431-13-14
7. Jeffries L, Milanese S, Grimmer-Somers K. Epidemiology of adolescent spinal pain. *Spine*. 2007;32(23):2630–2637. doi:10.1097/BRS.0b013e318158d70b
8. Joergensen AC, Hestbaek L, Andersen PK, *et al*. Epidemiology of spinal pain in children: a study within the Danish National Birth Cohort. *Eur J Pediatr*. 2019;178(5):695–706. doi:10.1007/s00431-019-03326-7
9. Papageorgiou AC, Croft PR, Ferry S, *et al*. Estimating the prevalence of low-back pain in the general population. Evidence from the South Manchester Back Pain Survey. *Spine*. 1995;20(17):1889–1894. doi:10.1097/00007632-199509000-00009
10. Watson KD, Papageorgiou AC, Jones GT, *et all*. Low-back pain in schoolchildren: occurrence and characteristics. *Pain*. 2002;97:87–92. doi:10.1016/s0304-3959(02)00008-8
11. Balague F, Skovron ML, Nordin M, *et al*. Low-back pain in school children: a study of familial and psychological factors. *Spine*. 1995;20:1265–70. doi:10.1097/00007632-199506000-00012
12. Salminen JJ, Pentti J, Terho P. Low-back pain and disability in 14-year-old schoolchildren. *Acta Paediatr*. 1992;81(12):1035–1039. doi:10.1111/j.1651-2227.1992.tb12170.x
13. Taimela S, Kujala UM, Salminen JJ, *et al*. The prevalence of low-back pain among children and adolescents: a nationwide, cohort-based questionnaire survey in Finland. *Spine*. 1997;22:1132–6. doi:10.1097/00007632-199705150-00013
14. Grimmer K, Williams M. Gender-age environmental associates of adolescent low-back pain. *Appl Ergon*. 2000;31:343–60. doi:10.1016/s0003-6870(00)00002-8
15. Skoffer B, Foldspang A. Physical activity and low-back pain in schoolchildren. *Eur Spine J*. 2008;17(3):373-379. doi:10.1007/s00586-007-0583-8
16. Jones GT, Watson KD, Silman AJ, *et al*. Predictors of low-back pain in British schoolchildren: A population-based prospective cohort study. *Pediatrics*. 2003;111(4):822-28. doi:10.1542/peds.111.4.822
17. Davis PJC, Williams HJ. The investigation and management of back pain in children. *Arch Dis Childh Edu Pract Ed*. 2008;93(3):73–83. doi:10.1136/adc.2006.115535
18. Lynch AM, Kashikar-Zuck S, Goldschneider KR, *et al*. Psychosocial risks for disability in children with chronic back pain. *J Pain*. 2006;7(4):244–51. doi:10.1016/j.jpain.2005.11.001
19. Yang S, Werner BC, Singla A, *et al*. Low back pain in adolescents: A 1-year analysis of eventual diagnoses. *J Pediatr Orthop*. 2017;37(5):344–347. doi:10.1097/BPO.0000000000000653.
20. Selbst SM, Lavelle JM, Soyupak SK, *et al*. Back pain in children who present to the emergency department. *Clin Pediatr (Phila)*. 1999;38(7):401–406. doi:10.1177/000992289903800704.
21. Calvo-Muñoz I, Kovacs FM, Roqué M, *et al*. Risk Factors for low back pain in childhood and adolescence: A systematic review. *Clin J Pain*. 2018;34(5):468–484. doi:10.1097/AJP.0000000000000558
22. Houghton KM. Review for the generalist: evaluation of low-back pain in children and adolescents. *Pediatr Rheumatol Online J*. 2010;8:28. doi:10.1186/1546-0096-8-28
23. Combs JA, Caskey PM. Back pain in children and adolescents: a retrospective review of 648 patients. *South Med J*. 1997;90(8):789–792. doi:10.1097/00007611-199708000-00004
24. Feldman DS, Hedden DM, Wright JG. The use of bone scan to investigate back pain in children and adolescents. J Pediatr Orthop. 2000;20(6):790–795. doi:10.1097/00004694-200011000-00018.
25. Minghelli B. Musculoskeletal spine pain in adolescents: Epidemiology of non-specific neck and low-back pain and risk factors. *J Orthop Sci*. 2020;25(5):776–780. doi:10.1016/j.jos.2019.10.008.
26. Kovacs FM, Abraira V, Peña A, *et al*. Effect of firmness of mattress on chronic non-specific low-back pain: randomised, double-blind, controlled, multicentre trial. *Lancet*. 2003;362(9396):1599–1604. doi:10.1016/S0140-6736(03)14792-7
27. Baker RJ, Patel D. Lower back pain in the athlete: common conditions and treatment. *Prim Care*. 2005;32(1):201–229. doi:10.1016/j.pop.2004.11.004
28. Feng Q, Jiang C, Zhou Y, *et al*. Relationship between spinal morphology and function and adolescent non-specific back pain: A cross-sectional study. *J Back Musculoskelet Rehabil*. 2017;30(3):625–633. doi:10.3233/BMR-160544
29. Jackson C, McLaughlin K, Teti B. Back pain in children: a holistic approach to diagnosis and management. *J Pediatr Health Care*. 2011;25(5):284–293. doi:10.1016/j.pedhc.2010.03.003

30. Prins Y, Crous L, Louw QA. A systematic review of posture and psychosocial factors as contributors to upper quadrant musculoskeletal pain in children and adolescents. *Physiother Theory Pract*. 2008;24(4):221–242. doi:10.1080/09593980701704089.

31. Yamato TP, Maher CG, Traeger AC, *et al*. Do schoolbags cause back pain in children and adolescents? A systematic review. *Br J Sports Med*. 2018;52(19):1241–1245. doi:10.1136/bjsports-2017-098927.

32. Will JS, Bury DC, Miller JA. Mechanical Low Back Pain. *Am Fam Physician*. 2018;98(7):421–428. PMID: 30252425.

33. Garvick SJ, Creecy C, Miller M, *et al*. Evaluating low-back pain in adolescents. *JAAPA*. 2019;32(12):14–20. doi:10.1097/01.JAA.0000604852.26078.91

34. Harreby M, Nygaard B, Jessen T, *et al*. Risk factors for low-back pain in a cohort of 1389 Danish school children: an epidemiologic study. *Eur Spine J*. 1999;8(6):444–450. doi:10.1007/s005860050203

35. Licciardone JC, Minotti DE, Gatchel RJ, *et al*. Osteopathic manual treatment and ultrasound therapy for chronic low-back pain: a randomized controlled trial. *Ann Fam Med*. 2013;11(2):122–129. doi:10.1370/afm.1468

36. Williams NH, Wilkinson C, Russell I, *et al*. Randomized osteopathic manipulation study (ROMANS): pragmatic trial for spinal pain in primary care. *Fam Pract*. 2003;20(6):662-669. doi:10.1093/fampra/cmg607

37. MacDonald J, Stuart E, Rodenberg R. Musculoskeletal low back pain in school-aged children: a review. *JAMA Pediatr*. 2017;171(3):280–287. doi:10.1001/jamapediatrics.2016.3334

38. Bijur PE, Silver W, Gallagher EJ. Reliability of the visual analog scale for measurement of acute pain. *Acad Emerg Med*. 2001; 8: 1153–1157. doi:10.1111/j.1553-2712.2001.tb01132.x

39. Keck JF, Gerkensmeyer JE,Joyce BA, *et al*. Validity of the Faces and Word Descriptor scales to measure procedural pain. *J Pediatr Nurs*. 1996;11:368–74. doi:10.1016/S0882-5963(96)80081-9

40. Garra G, Singer AJ, Taira BR, *et al*. Validation of the Wong-Baker FACES Pain Rating Scale in pediatric emergency department patients. *Acad Emerg Med*. 2010;17(1):50–54. doi:10.1111/j.1553-2712.2009.00620.x

41. Kordi R, Rostami M. Low-back pain in children and adolescents: an algorithmic clinical approach. *Iran J Pediatr*. 2011;21(3):259–270. PMID: 23056800.

42. Achar S, Yamanaka J. Back Pain in Children and Adolescents. *Am Fam Physician*. 2020;102(1):19-28. PMID: 32603067.

43. Satoh M, Chan EK, Ho LA, *et al*. Prevalence and sociodemographic correlates of antinuclear antibodies in the United States. *Arthritis Rheum*. 2012;64(7):2319–2327. doi:10.1002/art.34380

44. Michaleff ZA, Kamper SJ, Maher CG, *et al*. Low-back pain in children and adolescents: a systematic review and meta-analysis evaluating the effectiveness of conservative interventions. *Eur Spine J*. 2014;23(10):2046–2058. doi:10.1007/s00586-014-3461-1

45. O'Sullivan K, O'Keeffe M, Forster BB, *et al*. Managing low-back pain in active adolescents. *Best Pract Res Clin Rheumatol*. 2019;33(1):102–121. doi:10.1016/j.berh.2019.02.005

46. Pergolizzi JV Jr, LeQuang JA. Rehabilitation for low back pain: A narrative review for managing pain and improving function in acute and chronic conditions. *Pain Ther*. 2020;9(1):83–96. doi:10.1007/s40122-020-00149-5

47. Gordon R, Bloxham S. A systematic review of the effects of exercise and physical activity on non-specific chronic low back pain. *Healthcare (Basel)*. 2016;4(2):22. doi:10.3390/healthcare4020022

48. Standaert CJ, Herring SA, Pratt TW. Rehabilitation of the athlete with low-back pain. *Curr Sports Med Rep*. 2004;3(1):35–40. doi:10.1249/00149619-200402000-00007

49. Kim HJ, Green DW. Spondylolysis in the adolescent athlete. *Curr Opin Pediatr*. 2011;23(1):68–72. doi:10.1097/MOP.0b013e32834255c2

50. Kaelin AJ. Adolescent idiopathic scoliosis: indications for bracing and conservative treatments. *Ann Transl Med*. 2020;8(2):28. doi:10.21037/atm.2019.09.69

51. van der Gaag WH, Roelofs PD, Enthoven WT,*et al*. Non-steroidal anti-inflammatory drugs for acute low-back pain. *Cochrane Database Syst Rev*. 2020;4(4):CD013581. doi:10.1002/14651858.CD013581

52. Sairyo K, Nagamachi A. State-of-the-art management of low-back pain in athletes: Instructional lecture. *J Orthop Sci*. 2016;21(3):263-272. doi:10.1016/j.jos.2015.12.021

53. Task Force on the Low Back Pain Clinical Practice Guidelines. American Osteopathic Association Guidelines for Osteopathic Manipulative Treatment (OMT) for Patients With Low Back Pain. *J Am Osteopath Assoc*. 2016;116(8):536–549. doi:10.7556/jaoa.2016.107

54. Hayes NM, Bezilla TA. Incidence of iatrogenesis associated with osteopathic manipulative treatment of pediatric patients. *J Am Osteopath Assoc*. 2006;106(10):605-608. PMID:17122030

55. Dal Farra F, Risio RG, Vismara L, *et al*. Effectiveness of osteopathic interventions in chronic non-specific low-back pain: A systematic review and meta-analysis. *Complement Ther Med*. 2021;56:102616. doi:10.1016/j.ctim.2020.102616

56. Franke H, Franke JD, Fryer G. Osteopathic manipulative treatment for nonspecific low-back pain: a systematic review and meta-analysis. BMC Musculoskelet Disord. 2014;15:286. doi:10.1186/1471-2474-15-286

57. Licciardone JC, Brimhall AK, King LN. Osteopathic manipulative treatment for low-back pain: a systematic review and meta-analysis of randomized controlled trials. *BMC Musculoskelet Disord*. 2005;6:43. doi:10.1186/1471-2474-6-43

58. Kemper KJ, Vohra S, Walls R; Task Force on Complementary and Alternative Medicine; Provisional Section on Complementary, Holistic, and Integrative Medicine. American Academy of Pediatrics. The use of complementary and alternative medicine in pediatrics. *Pediatrics*. 2008;122(6):1374-1386. doi:10.1542/peds.2008-2173.

59. Black LI, Clarke TC, Barnes PM, *et al*. Use of complementary health approaches among children aged 4-17 years in the United States: National Health Interview Survey, 2007–2012. *Natl Health Stat Report*. 2015;(78):1–19. PMID: 25671583

60. Kaiser G, Degenhardt BF, Michael Menke J, *et al*. Characteristics and Treatment of Pediatric Patients in an Osteopathic Manipulative Medicine Clinic. *J Am Osteopath Assoc*. 2020;120(3):153–163. oi: 10.7556/jaoa.2020.028

61. Parnell Prevost C, Gleberzon B, Carleo B, *et al*. Manual therapy for the pediatric population: a systematic review. *BMC Complement Altern Med*. 2019;19(1):60. doi:10.1186/s12906-019-2447-2

62. Bolin DJ. The application of osteopathic treatments to pediatric sports injuries. *Pediatr Clin North Am*. 2010;57(3):775–794. doi:10.1016/j.pcl.2010.02.002

63. Brenner JS*et al*. Council on Sports Medicine and Fitness. Sports Specialization and Intensive Training in Young Athletes. *Pediatrics*. 2016;138(3):e20162148. doi:10.1542/peds.2016-2148. doi:10.1542/peds.2016-2148

64. DiFiori JP, Benjamin HJ, Brenner JS, *et al*. Overuse injuries and burnout in youth sports: a position statement from the American Medical Society for Sports Medicine. *Br J Sports Med*. 2014;48(4):287–288. doi:10.1136/bjsports-2013-093299

REVIEW ARTICLE

MULTIPLE SCLEROSIS: A COMPREHENSIVE REVIEW FOR THE OSTEOPATHIC PROVIDER

Ethan Charles Blocher-Smith, MS, DO[1,2]; Anthony Izokaitis, DO[1,2]

[1]Fruitport Family Medicine, Fruitport, MI
[2]Mercy Health Mercy Campus, Muskegon, MI

KEYWORD:

Multiple sclerosis

Multidisciplinary management

Osteopathic manipulative therapy

Abstract:

Multiple sclerosis (MS) is an uncommon neurological pathology frequently initially discovered by primary care providers in their workup of new focal neurological deficits. Many cases go undiagnosed for years despite multiple flares, with risk of cumulative disability. Early treatment is key to slowing or preventing the accumulation of this disability and maximizing function in the long term. This literature review covers all aspects of MS, including pathophysiology, diagnostic testing and differential diagnosis, disease classification, and disease-modifying agents for acute and chronic treatment. This study also summarizes support services, including osteopathic manipulative treatment, that help to maximize patient function and independence. While better therapeutics continue to emerge, significant limitations, side effects and continued progression—despite optimal therapy—result in progressive and irreversible loss of function for many patients. Heightened awareness of current progress in MS diagnosis criteria and initial testing amongst primary care providers can shorten the time to treatment and formal diagnosis, allowing patients to live their best lives despite their MS diagnosis.

INTRODUCTION

Multiple sclerosis (MS) is a complex disease state in which autoantibodies attack the central nervous system (CNS). These attacks result in progressive damage and subsequent disability, with eventual discovery typically coming from this disability. MS has an estimated minimum prevalence of 2.88 per 1000 individuals in the United States and, like most autoimmune conditions, is more likely in women with ~3:1 predominance.[1] The exact cause of this immune attack is unknown and appears to be multifactorial. There does appear to be a genetic component, as studies have shown a correlation between risk of MS in families proportional to amount of genetic similarity.[2] A monozygotic twin carries a risk of 25% for MS if their twin has the disease, which drops to around 5% for dizygotic twins or primary relatives, 1-2 percent for secondary relatives, and above base rate but less than 1% for tertiary relatives.[2] However, the low rates of incidence even with identical DNA imply a concomitant environmental component. Cases have been reported after Epstein–Barr virus,[3] human herpesvirus [64] and mycoplasma pneumoniae exposures,[5] implying a possible mechanism similar to that in type 1 diabetes with Coxsackie B virus,[6] with structures similar to that of the myelin sheath presenting on these agents to the immune system. Low vitamin D levels are shown to increase risk of MS,[7] with possible mechanism via immune cell activation on B/T cells and macrophages by vitamin D receptors.[8] This does also result in significant difference in MS prevalence based on latitude of primary residence. While several studies have argued that increased Vitamin D supplementation may modify MS severity, this is not conclusively proven with substantial disagreement in the literature at this time.[7] Smoking also appears to contribute, with history of smoking associated with relative risk of 1.5 for MS diagnosis, along with worsening frequency of relapse, higher conversion to progressive MS from remitting courses, and increased rate of disability accumulation.[9] There does appear to be an association with obesity as well, with a recent pediatric study showing twice the rate of MS in obese German children (OR 2.19 females, 2.14 males, $p \leq 0.003$) and worse response to first line agents in obese children, though whether this is causative or simply a secondary association is unknown.[10]

PATHOPHYSIOLOGY

While the initial cause of autoimmune attack is multifactorial and still not fully understood, the mechanism of injury and progression of an MS flare are well characterized. Classically, it was thought that CD4+ T-cells caused the injury in MS.[11] Further characterization has shown involvement of much of the immune system, with CD8+ T-cells, B-cells, Th1 and Th17 helper cells, CD4 and CD8+ T-regulatory cells, NK cells, mast cells, dendritic and microglial

CORRESPONDENCE:
Ethan Charles Blocher-Smith, MS, DO
eblochersmith756@marian.edu

 Print ISSN: 1877-573X
doi:10.33181/13079

cells, macrophages, among others.[12,13,14] These immune cells infiltrate a region within the CNS and attack nearby myelin sheaths and their supporting oligodendrocytes.[15] Depending on the severity of attack, this may only demyelinate a number of neurons resulting in temporary loss of their function until this sheath repairs itself across a period of weeks to months. In more severe episodes, however, this may progress to neuronal death, resulting in permanent loss of function.[15] As this attack increases in severity, the more temporary and permanent disability will occur with each episode. This accumulation of immune cells, damaged neurons, and surrounding inflammatory edema/cytokines results in characteristic plaques that are easily seen on MRI.[16] As the inflammation clears, glial cells proliferate to fill in any residual defect resulting in astrogliosis, leaving a permanent "scar" of the neural tissue.[16]

The exact loss of function resulting from a MS flare is dependent on the location of the immune attack. Occipital or medullary lesions may cause blindness or ophthalmoplegia, cerebellar lesions may cause poor balance, damage to the motor cortex or motor pathways in the spinal cord may cause paralysis, damage to frontal territories may affect behavior or mood, etc.[17] Due to the fact that every neurological system may be affected, initial diagnosis of MS may be very challenging. This is especially concerning, as every new attack without medication support is a roll of the dice to permanently lose CNS function.[18] Disability in MS is typically scored by the Kurtzke Expanded Disability Status Scale (EDSS) a scale that ranges from 0–10 as shown in Table 1.[19] Prior to the creation of modern therapies for treatment, mean progression of disability was estimated at 0.27 EDSS points every 2 years for patients with relapsing-remitting MS.[20] More recent studies have shown >50% of progressive MS cases will have EDSS >6 within 10 years of symptom onset.[21] Additionally, many patients may not realize the significance of early deficits, instead thinking that they are simply being clumsy or mistaking mood changes as a primarily psychological issue instead of the true neurological cause. As such, many primary care physicians (PCPs) may treat patients conservatively for an extended period before recognizing the significance of these disparate symptoms. A 2018 Swiss review of 1059 patients found only 62.7% of their patients were diagnosed within 2 years from initial symptoms, despite 90% having seen their PCP within the year prior to diagnosis.[22] Items from this study associated with a longer time to diagnoses were male sex, a general practitioner as the first provider contacted, and atypical symptoms from first episode.[22] Symptoms that are most common are those associated with the largest brain volume, since lesions may appear anywhere in the CNS. Thus, vision, balance, emotional and motor disturbances are most common, with hearing, speech, dysphagia, respiratory issues, or seizures less likely but still possible.[23] Aggressively treating to limit the level of immune destruction with intervention as soon as possible after diagnosis will reduce the rate of disability in both the short and long term.

TABLE 1:

EDSS Scale. The scale uses assessment in 8 functional systems (FS): Cognition and memory, pyramidal, sensory, visual, bowel/bladder function, cerebellar, brainstem, and other. A score of 4 or less is still fully ambulatory, with rapid loss of function at higher scores. In most studies, worsening disability is defined as a persistent increase in EDSS of 1 point or more.[19]

SCORE	DESCRIPTION
0	Normal neurological exam, no disability in any FS.
1.0	No disability, minimal signs in 1 FS.
1.5	No disability, minimal signs in >1 FS.
2.0	Minimal disability in 1 FS.
2.5	Mild disability in 1 FS or minimal disability in 2 FS.
3.0	Moderate disability in 1 FS, or mild disability in 3-4 FS. No impairment to walking.
3.5	Moderate disability in 1 FS and more than minimal disability in several others. No impairment to walking.
4.0	Significant disability but self-sufficient and mobile ≥12 hours a day. Able to walk without aid or rest for 500 m.
4.5	Significant disability but up and about much of the day, able to work a full day, may otherwise have some limitation of full activity or require minimal assistance. Able to walk without aid or rest for 300 m.
5.0	Disability severe enough to impair full daily activities and ability to work a full day without special provisions. Able to walk without aid or rest for 200 m.
5.5	Disability severe enough to preclude full daily activities. Able to walk without aid or rest for 100 m.
6.0	Requires a walking aid to walk about 100 m with or without resting.
6.5	Requires two walking aids to walk about 20 m without resting.
7.0	Unable to walk beyond ~5 m even with aid. Essentially restricted to wheelchair, wheeling self in standard wheelchair and transfers alone. Up and about in wheelchair ≥12 hours a day.
7.5	Unable to take more than a few steps. Restricted to wheelchair and may need aid in transferring. Can wheel self but cannot complete full day in standard and may require motorized wheelchair.
8.0	Essentially restricted to bed or chair or pushed in wheelchair. May be out of bed itself much of the day. Retains many self-care functions. Generally, has effective use of arms.
8.5	Essentially restricted to bed much of day. Has some effective use of arms retains some self-care functions.
9.0	Confined to bed. Can still communicate and eat.
9.5	Confined to bed and totally dependent. Unable to communicate effectively or eat/swallow.
10.0	Death due to MS.

DIAGNOSIS

The hallmark of MS is lesions disseminated in both space and time—first identified in 1965 by the panel of multiple sclerosis[24]—with diagnosis now most commonly occurring under the McDonald Criteria. Originally developed in 2001 by Professor Ian McDonald of London University, a New Zealand neurologist and the foremost expert of his time on MS, along with a team of experts, these guidelines are the standby for rigorous clinical diagnosis.[25] The most recent revision, published in 2017, focuses on diagnosis as early as possible while still meeting guidelines to prevent misdiagnosis.[26]

The standby of diagnosis is magnetic resonance imaging (MRI) evidence of lesions characteristic of MS, with 2 clinical attacks and evidence of 2 different lesions categorically defining MS.[25] However, these recent changes now allow detection of CSF specific oligoclonal bands to substitute for dissemination in time requirement, allowing diagnosis of MS with a single attack so long as at least 2 lesions are characterized at that time.[26] As previously mentioned, some patients may not have recognized a prior flare and its sequelae, allowing earlier diagnosis and treatment. Typical studies for a high index of suspicion for MS include MRI of the brain and/or spinal cord, CSF analysis with paired serum sample for oligoclonal band analysis, and evoked potential studies.[23] Early referral to neurology for assessment is also extremely important. These will now each be reviewed in detail.

MRI studies of the brain and spinal cord are ordered, as comprehensive evaluation of the CNS is appropriate to characterize all lesions for diagnosis. Additionally, use of gadolinium enhancement contrast can allow for differentiation of acute lesions with high uptake vs chronic lesions with gliosis scarring. Lesions are classified into 4 regions: periventricular, cortical/juxtacortical, infratentorial and spinal cord.[27] CSF analysis will show high protein secondary to albuminocytological dissociation. This finding, classically associated with Guillain-Barré syndrome, is positive in any CNS demyelinating process as the excess protein without cellular content is from the fragments of myelin sheath that have been destroyed.[28] Additionally, CSF specific oligoclonal bands, seen only in the CSF and not in the paired serum sample drawn concurrently, correspond to the IgG antibodies attacking the brain. In particularly severe cases, there may also be IgM antibodies that are CSF specific. This corresponds to much worse outcomes overall.[29] Evoked potential studies look at systems that are challenging to examine precisely and have a high risk of clinically occult deficits. This includes visual testing, auditory testing, brainstem evoking potentials, and somatosensory testing. For example, testing of vision involves use of visual stimulus with measured conductivity of the optic nerve pathway. This is an extremely sensitive test with any change to the nerve pathway resulting in measurable signal variance.[30] Lastly, autoantibody testing may come into play for differentiating alternative diagnoses in an atypical presentation for MS and would exclusively be ordered by a neurologist.

Disease classification

Multiple sclerosis may present as 1 of 4 categories of disease state (see Figure 1):

1. **Clinically Isolated Syndrome (CIS)**: This person has symptoms of MS lasting at least 24 hours but has not yet been formally diagnosed with a true MS diagnosis. This gateway diagnosis is placed on any individual who does not yet clearly meet both the dissemination in space and dissemination in time requirements for MS. Many people may never show a second episode and thus never qualify as MS. Many are properly differentially diagnosed with alternative conditions, such as optic neuritis, that have similar symptoms. However, individuals considered at high risk of progression to a formal MS diagnosis may receive disease-modifying drugs with full U.S. Food and Drug Administration (FDA) approval.[31]
2. **Relapsing Remitting Multiple Sclerosis (RRMS)**: This is the most common type of MS encompassing about 85% of patients with true MS diagnosis. This patient will have periodic episodes of MS flares, with partial to full recovery to prior baseline after each episode. They do not tend to worsen outside of individual flares, though each flare carries the risk of more persistent deficits and progressive debility and disability as more damage accumulates in the CNS.[31]
3. **Secondary Progressive Multiple Sclerosis (SPMS)**: This type of MS initially presents as RRMS but then worsens, with slow progressions of disability both with and without evidence of acute flares. While singular severe flares certainly still occur, the majority of disability and loss of function occurs as a slow worsening outside of these flares.[31]
4. **Primary Progressive Multiple Sclerosis (PPMS)**: This is the worst type of MS with rapid progression of disability. There is no respite period of RRMS initially, instead demonstrating the same constant accumulation of disability seen in SPMS. As with SPMS, this accumulation may happen independently of visualized new activity/lesions on MRI.[31]

Remember that just because a new lesion appears and there is new damage, the patient may not show symptoms. Similarly, new deficits may appear without new lesions due to worsening damage in existing territories.[31]

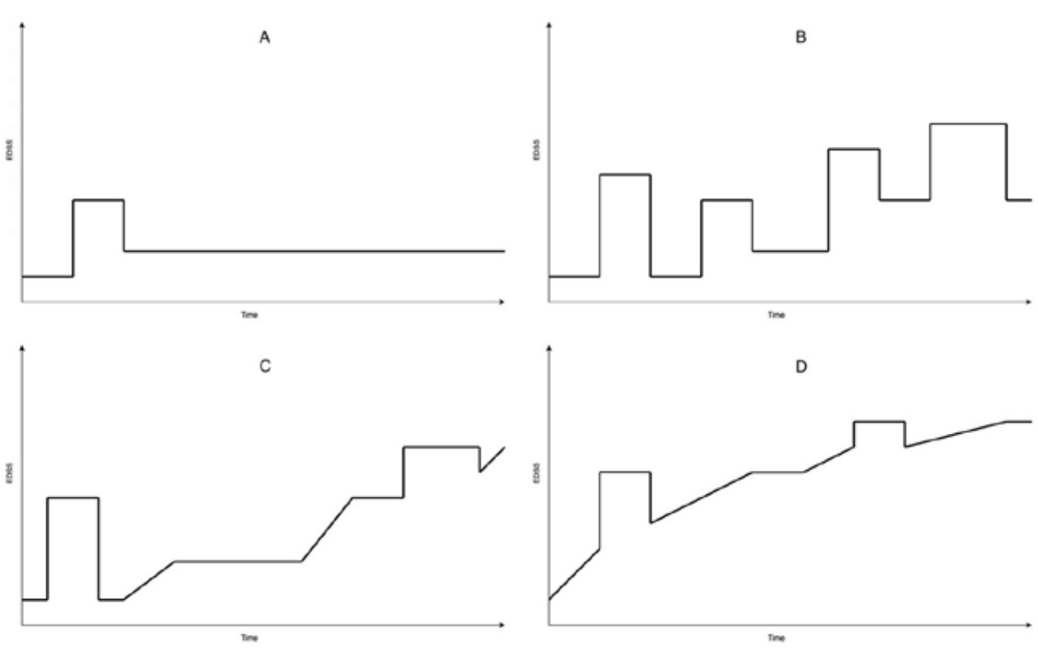
FIGURE 1:
Illustration of disease course for MS diagnoses.

FIGURE 1A:
CIS, in this case with persistent disability.

FIGURE 1B:
RRMS. Note return to baseline for flares 1 and 4, with disability progression for flares 2 and 3.

FIGURE 1C:
SPMS. Note RRMS final peak followed by start of constant disability accumulation. Once SPMS starts, in between flares is only ever worsening or flat.

FIGURE 1D:
PPMS, which starts immediately with constant progression and rapid deterioration.



Differential diagnoses

As would be expected in a condition with such a wide range of symptoms, the list of potential alternative diagnoses is extensive. Many other conditions may cause MRI enhancing lesions with acute deficits, such as tertiary syphilis, human immunodeficiency virus, human T-lymphotropic virus type 1 or Lyme disease.[32,33] Many alternative autoimmune conditions may also mimic this, such as sarcoidosis, lupus of the CNS, Sjögren's syndrome, Behçet's disease or vasculitis of the CNS.[32,34,35] Rarer inflammatory conditions—such as neuromyelitis optica spectrum disorder, acute disseminated encephalomyelitis or myelin oligodendrocyte glycoprotein-related demyelination—are also possible but outside the scope of this review. Nutritional deficits can mimic the neuropathy and myelopathy symptoms of MS, such as B12 and copper deficiency.[32,36,37] Lastly, sudden onset deficits should always raise concern for primary vascular cause, such as primary stroke, as well as rare diagnoses, including cerebral autosomal dominant arteriopathy with subcortical infarcts and leukoencephalopathy (CADASIL), which causes recurrent strokes with white matter lesions or retinocochleocerebral vasculopathy (Susac syndrome), which may cause sudden onset speech and hearing deficits.[32,38,39] Well-characterized MRI early in the disease course is most essential for effective differential diagnosis of these conditions. Nearly every case of MS will start showing symptoms between the ages of 20 and 50, with a vanishingly small number of cases in patients younger than 10 years old and 3.4% first diagnosed after 50.[1,40] However, due to the quality of new treatments and improved survivability, recent evaluations have shown peak prevalence in the 55–65 age group.[1]

TREATMENT

The top goals in multiple sclerosis are reducing number of flares, reducing severity of flares when they happen, and limiting persistent disability. These will each be discussed in turn. Nearly all medications that decrease frequency of flares also reduce severity, though some medications are used only for acute treatment of a new flare rather than for general prevention.[41]

TABLE 2:
Medications for MS management. Many additional medication trials exist, but only included those currently in phase 3 trials are included here. Many new medications seek to attack the Bruton's tyrosine kinase to reduce B-cells; however, no medication with this mechanism is currently FDA approved.

CLASS	GENERIC	BRAND	ROUTE	RRMS	SPMS	PPMS	2ND LINE
Sphingosine-1 Phosphate Receptor	Fingolimod	Gilenya®	Oral	X	X		
	Ozanimod	Zeposia®	Oral	X	X		
	Ponesimod	Ponvory®	Oral	X	X		
	Siponimod	Mayzent®	Oral	X	X		
Fumarate	Dimethyl Fumarate	Tecfidera®	Oral	X	X		
	Diroximel Fumarate	Vumerity®	Oral	X	X		
	Monomethyl Fumarate	Bafiertam®	Oral	X	X		
Dihydroorotate Dehydrogenase	Teriflunomide	Aubagio®	Oral	X	X		
Adenosine Analogue	Cladribine	Mavenclad®	Oral	X	X		X
Interferon Modulators	Interferon ß-1a	Avonex®	Injection	X	X		
		Rebif®	Injection	X	X		
	Peginterferon ß-1a	Plegridy®	Injection	X	X		
	Interferon ß-1b	Betaseron®	Injection	X	X		
		Extavia®	Injection	X	X		
Myelin Protein Inducers	Glatirimer Acetate	Copaxone®	Injection	X	X		
	Glatirimer Acetate	Glatopa®	Injection	X	X		
CD20 Targeting	Ofatumumab	Kesimpta®	Injection	X	X	X	
	Ocrelizumab	Ocrevus®	Injection	X	X		
	Ublituximab (Phase 3)	TG-1101	Oral	X			
CD52 Targeting	Alemtuzumab	Lemtrada®	Infusion	X	X		X
α4 Integrin Targeting	Natalizumab	Tysabri®	Infusion	X	X		
Antineoplastic DNA Crosslinking	Mitoxantrone	Novantrone®	Infusion	X	X		
Other	Evobrutinib (Phase 3)	M-2591	Oral	X			
	Tolebrutanib (Phase 3)	PRN-2246	Oral	X			
	Fenebrutanib (Phase 3)	RG-7845	Oral	X			

Direct immune modulation takes the form of oral, injectable, and infusion medications, as illustrated in Table 2. Medications targeting the sphingosine-1 phosphate receptors (-imod) work to decrease lymphocyte entry into the CNS by sequestration in the lymph nodes, thus reducing risk of damage.[42] Fumarate compounds are poorly understood but appear to modulate severity of inflammation from immune responses via antioxidative effect and are also commonly used in treatment of other inflammatory conditions like psoriasis.[43] Teriflunomide, similar to the agent leflunomide in rheumatoid arthritis, inhibits the DHO-DH enzyme resulting in impaired B- and T-cell production and suppressing immune response.[44] Cladribine is an adenosine analogue that is cytotoxic in its triphosphorylated form, though it only achieves this active form in cell lines that have low 5′-nucleotidase activity, such as lymphocytes, resulting in differential apoptosis of these immune cells.[45] However, cladribine is not perfectly targeted and thus has high risk of side effects due to cell death in other cell lines, making it a second line agent.[45]

Next, most injectable products focus on immune modulation via interferon beta. IFNß-1a is naturally produced in the human body, while IFNß-1b is a recombinant form of IFNß produced in E. coli. While the exact mechanism is not fully understood, IFNß reduces T-cell activity with emphasis on Th17, reduces pro-inflammatory cytokines and decreases lymphocyte entry into the CNS.[46] Alternatively, glatiramer acetate induces excess production of myelin sheath proteins, reducing damage to the actual myelin sheaths, while modulating immune response.[47]

Lastly, a number of monoclonal antibody products exist, all of which focus on destruction of lymphocytes. Several agents target CD20 which is expressed on B-cells resulting in focal destruction.[48] Another attacks CD52, an antigen present on most immune cells including B-/T-/NK-cells, monocytes, and macrophages.[49] Yet another attacks the α4 subunit of integrins, binding it and thus blocking the crossing of leukocytes through the blood-brain barrier.[50] Lastly, mitoxanantrone, an analogue of doxorubicin, directly attacks the cells via DNA crosslinking with strand breakage, destroying cell replication in immune cells and thus reducing them.[51] As with cladribine, this does result in some damage to other cells lines, resulting in this classification as a second line agent. Efficacy of these treatments shows that, roughly, monoclonal antibody treatments have the highest efficacy, followed by S1P receptor and fumarate drugs, with teriflunomide and the oldest standbys of INFß therapeutics and glatiramer with lowest benefit. This may change once the new oral drugs in Phase 3 trials are approved.

As many of these products diminish immune function, significant risk with infections or reactivation of chronically suppressed diseases is present. Most notably with drugs that block immune entry across the blood-brain barrier, this includes reactivation of the JC virus, resulting in progressive multifocal leukoencephalopathy (PML), which can be devastating to function and require cessation of therapy.[52] This does also include chronic hepatitis B and C reactivation,[53,54] varicella zoster,[55] and HHV-6,[56] among others.

Acute MS flares are treated with immune suppression, typically taking one of three forms. High dose IV/PO steroids were the first treatment identified and work well, however, many patients exist that may not be able to tolerate their side effects.[57] A similar option is use of high dose purified adrenocorticotropic hormone injections that induce the body to secrete steroids directly; however, this is very expensive and many locations do not have access to this therapy.[57] The last option is plasmapheresis which exchanges the plasma in the patient's blood to remove circulating antibodies, cytokines, and inflammatory biomarkers. This does have good evidence but is typically recommended when steroids are not sufficiently treating a flare.[57] IVIG has been trialed in the past but lacks high-quality evidence to support its use.

Outside of treating the underlying cause, medical therapy mainly focuses on treating the effects of MS flares to minimize disability. Optimal treatment for MS patients should include physical therapy to maximize function and accelerate return to maximal baseline.[58] This should also include occupational therapy as progressive accommodations will become necessary as disability accumulates to allow for best function and quality of life.[59] Key disability to watch for includes spastic bladder with bladder infections, loss of bowel control or motility, vertiginous symptoms, fatigue, new chronic pain and paresthesia, sexual functioning, muscular spasticity/tremors/gait problems and concomitant depression. An excellent summary of current medications for these symptoms and their use may be found through the National Multiple Sclerosis Society.[41] Dysphagia in MS is common with prevalence of 43%, requiring use of regular screening and speech-language pathology for evaluation and therapeutic treatment.[60]

Use of OMT for MS patients should focus on restoring as much homeostatic balance as possible. Because mobility is limited in many MS patients, opening the thoracic inlet is a low complexity intervention that can improve biomechanics and respirations along with lymphatic flow. Similarly, sacral rock/sacral wobble can help with parasympathetic tone and aid with GI functioning, which is likely to be affected either primarily by MS damage or secondarily by low gut motility from decreased activity overall.[61] Several pilot studies exist that look at other OMT interventions with improvement in quality of life overall. Additionally, assessment from OMT first principles would imply that use of counterstrain, muscle energy, the Still technique and others should be of use for the muscle tension and spasticity seen from loss of innervation or changes to gait mechanics from MS progression. This is likely to be a fruitful topic of future osteopathic research.

CONCLUSION

Multiple sclerosis is a complex autoimmune disease with each flare carrying the risk of additional disability. Early detection and awareness of the disease in the differential, even for common problems like anxiety/depression, gait changes, and tremor, is key for primary care providers. Imaging early with MRI if you have suspicion of MA is the mainstay for diagnosis, with more specialized labs such as CSF specific oligoclonal bands now playing an increased role in early diagnosis. DO providers should use OMT to help their patients with MS, along with utilizing a multidisciplinary team of physical therapists, occupational therapists, speech language pathologists, and other specialists to aid in maximizing function as the disease progresses. Refer to neurology early to get new therapeutics initiated. Most importantly as a DO, it is important to provide care to the entire patient, with emotional and spiritual support as necessary as the patient deals with a significant and debilitating diagnosis.

ACKNOWLEDGEMENTS: Special thanks to Lindsay Flegge, MSW, PhD, pain psychologist at Mary Free Bed and wife of the first author, for her work in editing for clarity and formatting of the manuscript of this paper.

DISCLOSURES AND FUNDING: The authors received no financial support related to this submission and have no financial affiliations or conflict of interest related to this article to disclose.

REFERENCES:

1. Wallin MT, Culpepper WJ, Campbell JD, *et al*. The prevalence of MS in the United States: A population-based estimate using health claims data. *Neurology*. 2019;92(10):e1029–e1040. doi:10.1212/WNL.0000000000007035
2. Willer CJ, Dyment DA, Risch NJ, Sadovnick AD, Ebers GC. Canadian Collaborative Study Group. Twin concordance and sibling recurrence rates in multiple sclerosis. *Proc Natl Acad Sci USA*. 2003;100(22):12877–12882. doi:10.1073/pnas.1932604100
3. Guan Y, Jakimovski D, Ramanathan M, Weinstock-Guttman B, Zivadinov R. The role of Epstein-Barr virus in multiple sclerosis: From molecular pathophysiology to in vivo imaging. *Neural Regen Res*. 2019;14(3):373–386. doi:10.4103/1673-5374.245462
4. Leibovitch EC, Jacobson S. Evidence linking HHV-6 with multiple sclerosis: An update. *Curr Opin Virol*. 2014;9:127–133. doi:10.1016/j.coviro.2014.09.016
5. Cossu D, Yokoyama K, Hattori N. Bacteria–host interactions in multiple sclerosis. Front. *Microbiol*. 9:2966. doi:10.3389/fmicb.2018.02966
6. Laitinen OH, Honkanen H, Pakkanen O, *et al*. Coxsackievirus B1 is associated with induction of ß-cell autoimmunity that portends type 1 diabetes. *Diabetes*. 2014;63(2):446–455. doi:10.2337/db13-0619
7. Sintzel MB, Rametta M, Reder AT. Vitamin D and multiple sclerosis: A comprehensive review. *Neurol Ther*. 2018;7(1):59–85. doi:10.1007/s40120-017-0086-4
8. Mora J, Iwata M, von Andrian U. Vitamin effects on the immune system: vitamins A and D take centre stage. *Nat Rev Immunol*. 2008;8(9):685–698. doi:10.1038/nri2378
9. Wingerchuk DM. Smoking: effects on multiple sclerosis susceptibility and disease progression. *Ther Adv Neurol Disord*. 2012;5(1):13–22. doi:10.1177/1756285611425694
10. Huppke B, Ellenberger D, Hummel H, *et al*. Association of obesity with multiple sclerosis risk and response to first-line disease modifying drugs in children. *JAMA Neurol*. 2019;76(10):1157–1165. doi:10.1001/jamaneurol.2019.1997
11. Kasper LH, Shoemaker J. Multiple sclerosis immunology: The healthy immune system vs the MS immune system. *Neurology*. 2010;74 Suppl 1:S2–8. doi:10.1212/WNL.0b013e3181c97c8f
12. Kouchaki E, Salehi M, Reza Sharif M, Nikoueinejad H, Akbari H. Numerical status of CD4(+)CD25(+)FoxP3(+) and CD8(+)CD28(-) regulatory T cells in multiple sclerosis. *Iran J Basic Med Sci*. 2014;17(4):250–255. PMID: 24904717
13. van Langelaar J, Rijvers L, Smolders J, van Luijn MM (2020) B and T cells driving multiple sclerosis: Identity, mechanisms and potential triggers. *Front Immunol*. 11:760. doi:10.3389/fimmu.2020.00760
14. Gandhi R, Laroni A, Weiner HL. Role of the innate immune system in the pathogenesis of multiple sclerosis. *J Neuroimmunol*. 2010;221(1–2):7–14. doi:10.1016/j.jneuroim.2009.10.015
15. Kurnellas MP, Donahue KC, Elkabes S. Mechanisms of neuronal damage in multiple sclerosis and its animal models: role of calcium pumps and exchangers. *Biochem Soc Trans*. 2007;35(Pt 5):923–926. doi:10.1042/BST0350923
16. Lassmann H. Multiple sclerosis pathology. *Cold Spring Harb Perspect Med*. 2018;8(3):a028936. doi:10.1101/cshperspect.a028936
17. Gelfand JM. Multiple sclerosis: diagnosis, differential diagnosis and clinical presentation. *Handb Clin Neurol*. 2014;122:269–290. doi:10.1016/B978-0-444-52001-2.00011-X
18. Langer-Gould A, Popat RA, Huang SM, *et al*. Clinical and demographic predictors of long-term disability in patients with relapsing-remitting multiple sclerosis: A systematic review. *Arch Neurol*. 2006;63(12):1686–1691. doi:10.1001/archneur.63.12.1686
19. Expanded Disability Status Scale (EDSS). Multiple Sclerosis Trust. https://mstrust.org.uk/a-z/expanded-disability-status-scale-edss. Published 01/2020.
20. Gani R, Nixon RM, Hughes S, Jackson CH. Estimating the rates of disability progression in people with active relapsing-remitting multiple sclerosis. *Journal of Medical Economics*. 2007;10(2):79-89. doi:10.3111/200710079089
21. Paz Soldán MM, Novotna M, Abou Zeid N, *et al*. Relapses and disability accumulation in progressive multiple sclerosis. *Neurology*. 2015;84(1):81–88. doi:10.1212/WNL.0000000000001094
22. Kaufmann M, Kuhle J, Puhan MA, *et al*. Factors associated with time from first-symptoms to diagnosis and treatment initiation of Multiple Sclerosis in Switzerland. *Mult Scler J Exp Transl Clin*. 2018;4(4):2055217318814562. doi:10.1177/2055217318814562
23. Ghasemi N, Razavi S, Nikzad E. Multiple sclerosis: Pathogenesis, symptoms, diagnoses and cell-based therapy. *Cell J*. 2017;19(1):1–10. doi:10.22074/cellj.2016.4867
24. Schumacher GA, Beebe G, Kibler RF, *et al*. Problems of experimental trials of therapy in multiple sclerosis: Report by the panel on the evaluation of experimental trials of therapy in multiple sclerosis. *Ann N Y Acad Sci*. 1965;122:552–568. doi:10.1111/j.1749-6632.1965.tb20235.x
25. McDonald WI, Compston A, Edan G, *et al*. Recommended diagnostic criteria for multiple sclerosis: Guidelines from the international panel on the diagnosis of multiple sclerosis. *Ann Neurol*. 2001;50(1):121–127. doi:10.1002/ana.1032
26. Carroll WM. 2017 McDonald MS diagnostic criteria: Evidence-based revisions. *Mult Scler*. 2018;24(2):92–95. doi:10.1177/1352458517751861
27. Wattjes MP, Ciccarelli O, Reich DS, *et al*. 2021 MAGNIMS-CMSC-NAIMS consensus recommendations on the use of MRI in patients with multiple sclerosis. *Lancet Neurol*. 2021;20(8):653–670. doi:10.1016/S1474-4422(21)00095-8
28. Brooks JA, McCudden C, Breiner A, Bourque PR. Causes of albuminocytological dissociation and the impact of age-adjusted cerebrospinal fluid protein reference intervals: A retrospective chart review of 2627 samples collected at tertiary care centre. *BMJ Open*. 2019;9(2):e025348. doi:10.1136/bmjopen-2018-025348
29. Deisenhammer F, Zetterberg H, Fitzner B, Zettl UK. The cerebrospinal fluid in multiple sclerosis. *Front Immunol*. 2019;10:726. doi:10.3389/fimmu.2019.00726
30. Comi G, Leocani L, Medaglini S, *et al*. Measuring evoked responses in multiple sclerosis. *Mult Scler*. 1999;5(4):263–267. doi:10.1177/135245859900500412

31. Lublin FD, Reingold SC, Cohen JA, *et al*. Defining the clinical course of multiple sclerosis: The 2013 revisions. *Neurology*. 2014;83(3):278–286. doi:10.1212/WNL.0000000000000560

32. Ömerhoca S, Akkaş SY, İçen NK. Multiple sclerosis: Diagnosis and differential diagnosis. Noro Psikiyatr Ars. 2018;55(Suppl 1):S1–S9. doi:10.29399/npa.23418

33. Lindland ES, Solheim AM, Andreassen S, *et al*. Imaging in Lyme neuroborreliosis. *Insights Imaging*. 2018;9(5):833–844. doi:10.1007/s13244-018-0646-x

34. Uygunoğlu U, Siva A. Behçet's syndrome and nervous system involvement. *Curr Neurol Neurosci Rep*. 2018;18(7):35. doi:10.1007/s11910-018-0843-5

35. Kim SS, Richman DP, Johnson WO, Hald JK, Agius MA. Limited utility of current MRI criteria for distinguishing multiple sclerosis from common mimickers: primary and secondary CNS vasculitis, lupus and Sjogren's syndrome. *Mult Scler*. 2014;20(1):57–63. doi:10.1177/1352458513491329

36. Briani C, Dalla Torre C, Citton V, et al. Cobalamin deficiency: clinical picture and radiological findings. Nutrients. 2013;5(11):4521–4539. doi:10.3390/nu5114521

37. Plantone D, Primiano G, Renna R, *et al*. Copper deficiency myelopathy: A report of two cases. *J Spinal Cord Med*. 2015;38(4):559–562. doi:10.1179/2045772314Y.0000000268

38. Stojanov D, Vojinovic S, Aracki-Trenkic A, *et al*. Imaging characteristics of cerebral autosomal dominant arteriopathy with subcortical infarcts and leucoencephalopathy (CADASIL). *Bosn J Basic Med Sci*. 2015;15(1):1–8. doi:10.17305/bjbms.2015.247

39. Algahtani H, Shirah B, Amin M, Altarazi E, Almarzouki H. Susac syndrome misdiagnosed as multiple sclerosis with exacerbation by interferon beta therapy. *Neuroradiol J*. 2018;31(2):207–212. doi:10.1177/1971400917712265

40. Roohani P, Emiru T, Carpenter A, *et al*. Late onset multiple sclerosis: Is it really late onset? *Mult Scler Relat Disord*. 2014;3(4):444–449. doi:10.1016/j.msard.2014.02.004

41. Medications. National Multiple Sclerosis Society. https://www.nationalmssociety.org/Treating-MS/Medications.

42. Chaudhry BZ, Cohen JA, Conway DS. Sphingosine 1-Phosphate receptor modulators for the treatment of multiple sclerosis. *Neurotherapeutics*. 2017;14(4):859–873. doi:10.1007/s13311-017-0565-4

43. Mills EA, Ogrodnik MA, Plave A, Mao-Draayer Y. Emerging understanding of the mechanism of action for dimethyl fumarate in the treatment of multiple sclerosis. *Front Neurol*. 2018;9:5. doi:10.3389/fneur.2018.00005

44. Bar-Or A, Pachner A, Menguy-Vacheron F, Kaplan J, Wiendl H. Teriflunomide and its mechanism of action in multiple sclerosis. *Drugs*. 2014;74(6):659–674. doi:10.1007/s40265-014-0212-x

45. Leist TP, Weissert R. Cladribine: Mode of action and implications for treatment of multiple sclerosis. Clin Neuropharmacol. 2011; 34(1): 28–35. doi:10.1097/WNF.0b013e318204cd90

46. Dhib-Jalbut S, Marks S. Interferon-ß mechanisms of action in multiple sclerosis. *Neurology*. 2010;74(1 Supplement 1):S17–S24. doi:10.1212/WNL.0b013e3181c97d99

47. Weber MS, Hohlfeld R, Zamvil SS. Mechanism of action of glatiramer acetate in treatment of multiple sclerosis. *Neurotherapeutics*. 2007;4:647–653. doi:10.1016/j.nurt.2007.08.002

48. Boross P, Leusen JH. Mechanisms of action of CD20 antibodies. Am J Cancer Res. 2012;2(6):676–690. PMID: 23226614

49. Hu Y, Turner MJ, Shields J, et al. Investigation of the mechanism of action of alemtuzumab in a human CD52 transgenic mouse model. Immunology. 2009;128(2):260–270. doi:10.1111/j.1365-2567.2009.03115.x

50. González-Amaro R, Mittelbrunn M, Sánchez-Madrid F. Therapeutic anti-integrin (alpha4 and alphaL) monoclonal antibodies: two-edged swords?. Immunology. 2005;116(3):289–296. doi:10.1111/j.1365-2567.2005.02225.x

51. Fox EJ. Mechanism of action of mitoxantrone. *Neurology*. 2004;63(12 Suppl 6):S15–S18. doi:10.1212/wnl.63.12_suppl_6.s15

52. Williamson EML, Berger JR. Diagnosis and treatment of progressive multifocal leukoencephalopathy associated with multiple sclerosis therapies. *Neurotherapeutics*. 2017;14(4):961–973. doi:10.1007/s13311-017-0570-7

53. Tagawa A, Ogawa T, Tetsuka S, *et al*. Hepatitis C virus (HCV) reactivation during fingolimod treatment for relapsing and remitting multiple sclerosis. *Mult Scler Relat Disord*. 2016;9:155–157. doi:10.1016/j.msard.2016.08.003

54. Ciardi MR, Iannetta M, Zingaropoli MA, *et al*. Reactivation of Hepatitis B Virus With Immune-Escape Mutations After Ocrelizumab Treatment for Multiple Sclerosis. *Open Forum Infect Dis*. 2018;6(1):ofy356. doi:10.1093/ofid/ofy356

55. Arvin AM, Wolinsky JS, Kappos L, *et al*. Varicella-zoster virus infections in patients treated with fingolimod: risk assessment and consensus recommendations for management. *JAMA Neurol*. 2015;72(1):31–39. doi:10.1001/jamaneurol.2014.3065

56. Yao K, Gagnon S, Akhyani N, et al. Reactivation of human herpesvirus-6 in natalizumab treated multiple sclerosis patients. PLoS One. 2008;3(4):e2028. doi:10.1371/journal.pone.0002028

57. Ontaneda D, Rae-Grant AD. Management of acute exacerbations in multiple sclerosis. *Ann Indian Acad Neurol*. 2009;12(4):264–272. doi:10.4103/0972-2327.58283

58. Řasová K, Freeman J, Cattaneo D, *et al*. Content and delivery of physical therapy in multiple sclerosis across Europe: A survey. *Int J Environ Res Public Health*. 2020;17(3):886. doi:10.3390/ijerph17030886

59. Quinn É, Hynes SM. Occupational therapy interventions for multiple sclerosis: A scoping review. *Scand J Occup Ther*. 2021;28(5):399–414. doi:10.1080/11038128.2020.1786160

60. Ansari NN, Tarameshlu M, Ghelichi L. Dysphagia in multiple sclerosis patients: Diagnostic and evaluation strategies. *Degener Neurol Neuromuscul Dis*. 2020;10:15–28. doi:10.2147/DNND.S198659

61. Wolf K, Krinard T, Talsma J, Pierce-Talsma S. OMT for patients with multiple sclerosis. *J Am Osteopath Assoc*. 2017;117(12):e141. doi:10.7556/jaoa.2017.153

REVIEW ARTICLE

THE IMPACT OF CLIMATE CHANGE ON OUR PATIENTS' HEALTH AND THE FAMILY PHYSICIAN'S ROLE

Raena M. Pettitt, DO[1]; Tharini M. Gara, OMS-IV[1]; Meghan E. Izak, OMS-IV[1]; Ethan R. Steele, OMS-IV[1]

[1] Liberty University College of Osteopathic Medicine, Lynchburg, VA

KEYWORD:

Climate change

Abstract:

Climate change continues to have a detrimental effect on the overall health of people globally. The average yearly temperature has continually risen since the late 19th century and is projected to continue rising for decades ahead. Increased temperature has been linked to decreased sleep quality and increased heat strokes and pregnancy complications.

Adverse effects on cardiopulmonary health have been linked to climate change. Air pollution is correlated to an increased risk of myocardial infarctions and aggravation of symptoms pertaining to asthma and chronic obstructive pulmonary disorder. Lengthening of the pollination season because of warmer weather due to climate change has led to an increase in allergy-related rhinitis and asthma.

Temperature increases have caused a lengthening of the transmission season of infectious disease, especially vector and water-borne diseases. Infectious disease has begun to spread to new areas globally due to increased temperatures, rainfall and flooding attributed to climate change.

The mental health impacts attributed to climate change, including depression and anxiety, are escalating. With increased floods and hurricanes, people of certain geographic areas can experience an increase in acute stress, which may lead to chronic post-traumatic stress disorder.

Family physicians are at the forefront of advising patients on how to handle the health effects of climate change. In addition to climate change's impact on health, patients of lower socioeconomic status are more at risk because of lack of adequate resources and financial stability. Through detailed histories, family physicians have an opportunity to identify affected patients and intervene earlier.

INTRODUCTION

Scientific researchers have tried for many years to explain why the Earth's overall temperature is rising, a critical component of climate change. Since the middle of the 19th century, an overall increase of greenhouse gas emissions into the Earth's atmosphere has caused a consistent rise in the average yearly temperature of the Earth.[1] Warming of the Earth caused by climate change has led to both acute and chronic changes to the Earth's ecosystem. Acute changes include increased natural disasters, flooding, and heat waves while chronic changes include increased pollution and creation of environments more suitable for pathogens.[1] These chronic and acute changes to the Earth can cause drastic direct and indirect effects on the health of humans.[2]

Every American's health is at risk of being impacted by climate change. However, there seems to be external factors not directly related to climate change that can contribute to the increased risk of health consequences. People with lower socioeconomic statuses were shown to have a higher likelihood of having their health impacted by climate change. More specifically, in urban populations, there is a higher risk of health issues from climate change in lower socioeconomic areas due to less green space, fewer community resources, and inability to attain adequate help to address their health problems.[3] In addition, a study based in the southeast United States showed the presence of a higher number of people living below the poverty line in rural populations. These communities may have a lower ability to respond to the health burdens imposed by climate change, like increased heat and weather variations.[4]

CORRESPONDENCE:
Raena M. Pettitt, DO | rmpettitt@liberty.edu

 Print ISSN: 1877-573X
doi:10.33181/13080

Even though researchers have started to uncover the effects that climate change has had on human health, it is still difficult to formally attribute health outcomes solely due to climate change. Many health-related burdens due to climate change can be classified as climate-sensitive or climate-induced. Climate-sensitive illnesses can be exacerbated by the consequences of climate change and include cardiovascular, pulmonary, and renal diseases. Climate-induced illnesses can be linked directly to the consequences created by climate change and include heat stroke, malnutrition, and mental illness.[5] This is significant for healthcare providers, especially family medicine physicians who are the first-line defense as they see a vast array of clinical cases. With increased mortality and morbidity now being associated with climate change, new research and data can help family medicine physicians with the diagnosis, management, and treatment of future patients with climate-change provoked diseases.[6]

HEAT

On average, temperatures in the United States have risen 1.3–1.9°F (0.72–1.06°C) since 1895 and are estimated to continue to increase 2–4 degrees over the next few decades. These increasing temperatures lead to extreme heat-related events, such as heat strokes, which is the most prominent cause of weather-related deaths.[7] Deaths from heat strokes are often associated with agricultural workers because they continue to work despite feeling ill. The southeast and southwest portions of the United States are the areas at most risk of these increasing temperatures, where hot and humid work conditions increase health risk.8 Studies in the central valley of California show migrant farm workers have been developing acute and chronic kidney disease at higher rates due to increased prevalence of heat waves in this area.[9] This increase in renal disease could potentially be caused by chronic dehydration due to heat stress, because these workers spend the majority of time outside.[9]

Heat itself has also been tied to decreased sleep quality, duration of sleep, and increased rates of obstructive sleep apnea.[7] Negative effects of increased temperature have also begun to impede on city areas due to increased amounts of black pavement which absorb and trap heat. This phenomenon, called the "heat-island effect," coupled with a decrease in the amounts of trees in cities, further contribute to increases in temperature.[10]

Multiple studies have also investigated heat-related increases in preterm births. Increases in temperature due to climate change were correlated with decreased birth weights, decreased gestational length, increased risk of stillbirth, and an increase in neonatal stress and mortality.[11]

NUTRITION

Of the many implications of climate change, its effect on food resources is a topic gaining immense traction. Due to climate change's correlation with increased temperatures, rainfall and CO2 levels, this poses problems with agriculture, potentially impacting nutrition. Many effects of climate change can alter crop yield, nutrient value, protein content and even livestock. Furthermore, climate change is attributed to a decreased amount of animal pollination, which can potentially impact patients. Growing research shows possible contributions to altered levels of micronutrients in crops, such as folic acid, which could lead to birth defects.[12] The increases in CO2 concentrations can also potentially change nutritional value by decreasing protein content in crops by 7%–15%. This can cause patients susceptible to malnutrition to not meet their daily intake of protein. Additionally, decreases in zinc and iron levels in cereals and legumes, as well as a decrease in phosphorus and potassium, can cause individuals to have a deficiency in these minerals.[12]

Studies based on models accounting for CO2 levels, water nitrogen, and temperature also project how climate change would affect the wheat grain protein concentration, which is amongst the three main sources of human nutrition. It was found that areas with low and mid-latitude locations, such as Texas, Florida and North Carolina, show a negative correlation to grain yield and protein concentration. In contrast, high-latitude locations, such as states along the northern border of the United States, show a more positive yield, once again interplaying with proper nutritional value.[13]

CARDIOPULMONARY

Cardiopulmonary systems are affected by climate change through air pollution, extreme temperatures, sand dust storms, and wildfires. Air pollution is assessed using fine particulate matter (PM2.5) and ground level ozone (O3). $PM_{2.5}$ comes from ambient air pollution and causes the greatest threat to public health.[14,15] Particles with a diameter less than 2.5 μm can travel into bronchioles and alveoli and cause systemic oxidative stress and inflammation.[16,17] O_3, likewise, is a harmful oxidizing agent and the primary constituent of smog.[18,19] Measurements of $PM_{2.5}$ and O3 show that air quality worsens as areas become more urban.[19] Air pollution is associated with increased emergency department visits, asthma and chronic obstructive pulmonary disease (COPD) exacerbations, and higher risks of myocardial infarctions.[14,15,18–21] Inhaled pollutants can increase the risk of myocardial infarctions by causing atherothrombosis through systemic inflammatory responses, sympathetic nervous system activation, and the direct result of pollutants in systemic circulation.[20]

Exposure to extreme temperatures, sand dust storms and wildfires are becoming more frequent and are affecting more individuals. Severe heat waves and cold spells lead to dehydration and force the human body to activate the sympathetic nervous system and renin-angiotensin system. During a heat stroke, a systemic inflammatory response may result as the body attempts to reduce its core temperature. These adaptations can explain the association between extreme temperatures and increased morbidity and mortality of cardiovascular disease.[20] Both temperature extremes, as well as transitions and variability in temperature, may trigger acute myocardial infarctions and are associated with increases in morbidity and mortality in individuals with COPD.[16,18]

During the spring and summer months, sand dust storms are a rising threat in states like Arizona, California, Washington and Nevada. Dust storms are hazardous to cardiopulmonary health because they increase $PM_{2.5}$. The inhaled particles damage bronchial epithelial cells and attract immune cells leading to increased hospitalizations in asthma and COPD patients and an increased risk for myocardial infarctions.[14,17] The dust also increases the risk for infectious diseases such as influenza, coccidioidomycosis, bacterial pneumonia and meningococcal meningitis.[17]

Finally, wildfire activity has increased over the past decades, affecting multiple western states. While the rest of the country is decreasing in $PM_{2.5}$, wildfires are believed to be the cause of $PM_{2.5}$ increases in the Northwest.[22] There has been consistent evidence that wildfire air pollution leads to exacerbation of asthma. Associations between increased exacerbation of COPD or respiratory infections and wildfire pollution have been neither clear nor consistent within recent literature.[23]

ALLERGIES

Due to industrialization, increasing fossil fuel consumption has led to high levels of CO_2.[24] High CO_2, coupled with warmer temperatures, contributes to the promotion of plant growth and elongation of the pollen season. This is due to plants flowering earlier in the spring with warmer weather and surviving longer into fall with a delayed first frost.[24,25] Not only has the pollen season been prolonged, but the pollen load in certain plants has increased as well. There is also a suspected increase in the allergenicity of the pollen being produced. These effects are contributing to more and worsening allergic diseases, such as asthma.[25]

Pollen is not the only factor of climate change that can affect allergies. Heat stress and ground level ozone both promote inflammation and, therefore, are associated with increased allergic responses.[24] Additionally, as areas of the country experience more precipitation, humidity, flooding, and subsequently, an increase in indoor moisture, fungal growth and inhalation of fungal components can increase. These inhaled fungal components activate the immune system and can lead to allergic rhinitis and asthma exacerbations.[24,26]

INFECTIOUS DISEASE

Vector-borne infectious diseases are anticipated to continue globally spreading as the zone of optimal temperature for vector survival and pathogen transmission moves away from the equator and toward the hemispheres.[27,28] Transmission seasons, which occur from spring through fall, and geographical ranges of diseases will continue to change as temperate regions experience warmer temperatures, milder winters, and more rainfall.[28–30] It is important to analyze vector response to climate change separately. For example, malaria, West Nile, Zika, dengue, chikungunya and yellow fever viruses are all spread through mosquitoes, while Lyme disease is spread through different regional ticks. Because of their life cycles and feeding patterns, mosquito populations can respond rapidly to acute climate variability, like temperature fluctuations, and can cause both short-term and long-term epidemics. In contrast, increased tick populations result from chronic climate changes, like progressive increases in temperature and humidity in a region.[27] As vector-borne diseases spread to new areas or when individuals travel to areas endemic with disease without acquired immunity, they are more likely to experience more severe symptoms if they contract the disease.[30] Fortunately, socioeconomic factors like public health services, education, housing infrastructure and drug availability will likely deter disease spread in the United States. However, extreme weather like flooding can hinder adequate vector control.[29,30]

Warmer temperatures, as well as an increase in rainfall and flooding, are believed to increase the incidence of waterborne diseases because they increase pathogen survival and replication and can increase expression of virulence genes in bacterial pathogens.[31,32] Increased temperatures also affect human behavior, as individuals consume more water during warmer temperatures, thus causing an increase in the probability of pathogen ingestion.[31] Increased rainfall and flooding can transport pathogens, contaminate groundwater and overwhelm water treatment infrastructure.[31,32] The increased incidence of waterborne diseases after a heavy rain can be intensified when there is a significant dry period preceding it, allowing for an increased concentration of pathogens. When there is heavy rainfall, these pathogens can be spread by the increased flow of water.[32] Heavy rainfall can also carry protozoan pathogens from manure and can contaminate fresh produce.[31] Finally, flooding can cause the displacement of affected people to temporary communities with inadequate sanitation and water treatment systems.[31]

MENTAL HEALTH

An often-overlooked impact of climate change is its effects on mental health. These climate related events can lead to displacement of individuals from their homes, stress and mental health problems, such as depression, anxiety and post-traumatic stress disorder (PTSD). Extreme weather is estimated to produce negative mental health outcomes in about 25%–50% of individuals within the first year after the event.[33]

Amongst patients who experience a flood, 30%–40% are diagnosed with PTSD. Initial trauma from the climate change event may cause an acute stress disorder, which can ultimately lead to PTSD.[33] Patients affected by flooding are said to experience PTSD at an eight times higher rate than those from homes that were not affected.[34] A study done after Hurricane Katrina in New Orleans showed 20%–35% survivors had mental health disorders afterwards. Amongst these survivors, half of them with PTSD came from marginalized communities, mainly low-income African American women.[35]

Increasing temperatures alone can take a substantial toll on an individual's mental health. Extreme heat and humidity have increased the amount of hospital admissions for patients with mood and behavioral disorders, such as schizophrenia, mania, and neuroticism. Thermoregulation can be affected in patients with pre-existing mental illnesses, chronic medication use, or substance abuse, thus further contributing to the susceptibility to heat-related morbidity.[35]

more than twenty-five days of precipitation. This data suggests that the southern United States during the spring and summer months will be more susceptible.[36]

Newer terminology has been developed to further define some of the possible mental health outcomes from climate change. These mental health issues can stem from what is known as psychoterratic syndromes. These syndromes include ecoanxiety, defined as the anxiety brought on by climate change, and ecoparalysis, which is defined as one's non-effectiveness in having control over climate change. Extreme weather events associated with climate change may cause another syndrome known as solastalgia, which is described as the stress from the progressive loss of solace from one's surroundings.[35]

Similar to adults, children are susceptible to the mental health effects of climate change. Children are a lot more aware of the world around them and have an increased expression of fear and worry towards their future due to climate change.[37]

ROLE OF THE FAMILY PHYSICIAN

The family physician's priority is their patients' health, so it is important to be well informed on everyday aspects of living that can affect their patient's quality of life. Family physicians can directly impact these changes by implementing green practices, such as telemedicine into their practice. This is noteworthy since healthcare delivery can be attributed to 10% of the greenhouse emissions.[38] The effects of climate change can offer a unique opportunity for family physicians to play a significant role in healthcare.

A study performed in Wisconsin surveyed family physicians about the effects of climate change in their community. The results showed that 64% of physicians reported that climate change affected their patient's health. However, only 33% of physicians reported feeling very well or well informed on the health impacts of climate change. Moreover, 17% of physicians felt extremely or somewhat comfortable counseling patients on climate change and health.[39] Family physicians felt that continued medical education courses regarding the health effects of climate change would benefit their patient care.[40]

There are many ways that family physicians can evaluate patients affected by climate change and even prevent potential adverse outcomes. Thorough histories, especially regarding mental health in relation to climate change, can aid in early intervention and counseling. If mental health issues are identified, it is important to offer early and prompt treatment or refer these patients for additional care if needed, such as counseling.[41] Table 1 outlines the various interventions and educational opportunities that can be implemented by family physicians.

TABLE 1:[7,9,11,12,14-21,23-33,41-42]

The Physician's Response to Climate Change Health Outcomes

CLIMATE CHANGE CONCERN	CLINICAL IMPACTS	PHYSICIAN'S ROLE
Heat	Heat stroke, AKD, CKD, altered sleep quality, pre-term births	Advise patients of the signs and symptoms of heat stroke and emphasize the importance of adequate hydration Inquire about previous geographic locations in agricultural workers Counsel outdoor workers in the importance of breaks and avoidance of outdoor activity at peak temperatures During heat waves, advise patients to seek cooler places, such as those with air conditioning Educate pregnant patients on potential pregnancy risks associated with extensive heat exposure
Nutrition	Malnutrition, mineral deficiencies in zinc, iron, potassium, and phosphorus	Educate the patient on potential nutritional effects of climate change Encourage the consumption of foods rich in minerals
Cardiopulmonary	Asthma and COPD exacerbations, increased risk of myocardial infarction	Encourage monitoring of local air quality and temperatures Promote indoor activities when conditions are suboptimal N95 masks may be useful when air quality is poor such as during wildfires
Allergies	Allergic responses, asthma exacerbations	Encourage the patient to monitor pollen counts and maximize treatment options for symptom control Following heavy precipitation and flooding, discussions regarding mold growth in homes may be warranted

TABLE 1 CONT'D

Infectious diseases	Vector-borne and water-borne diseases	Proper clothing and repellents should be advised for outdoor activities Education on signs and symptoms may lead to early detection and treatment of diseases Caution patients that local produce may become contaminated after heavy rainfall
Mental health	Depression, anxiety, post-traumatic stress disorder	Especially following natural disasters, screening and proper referrals are essential

CONCLUSION

Climate change is a global issue that will continue to take a toll on human lives. The World Health Organization has predicted that between the years 2030 and 2050, up to 250,000 additional deaths per year will be attributable to climate change.[39] These statistics bring awareness to the impact of climate change and its consequences. For example, companies who have employees working in high heat conditions should take into account that their workers are at a higher risk of getting heat stroke. Therefore, employers should have resources available on job sites to prevent symptoms of heat stroke.

It is important for physicians to become aware of the toll climate change is having on their patients. This especially pertains to family medicine physicians, who see a wide array of clinical presentations throughout their practice. With the majority of their clinical cases involving mental health, cardiopulmonary, allergies, and infectious disease topics, it would be advantageous for family medicine physicians to understand the impacts that climate change can have on patients.

Climate change can affect many aspects of health. Increasing public and physician awareness is fundamental to offset these potential health issues. Continued research and analysis are needed to uncover more information regarding climate change, and more importantly, ways to improve and protect the comprehensive health of all.

FUNDING AND DISCLOSURES: The authors received no financial support related to this submission and have no financial affiliations or conflict of interest related to this article to disclose.

REFERENCES

1. Rossati A. Global warming and its health impact. *Int J Occup Environ Med*. 2017;8(1):7–20. doi:10.15171/ijoem.2017.963
2. Wheeler N, Watts N. Climate change: From science to practice. *Curr Environ Health Rep*. 2018;5(1):170–178. doi:10.1007/s40572-018-0187-y
3. Fagliano JA, Diez Roux AV. Climate change, urban health, and the promotion of health equity. *PLoS Med*. 2018;15(7):e1002621. doi:10.1371/journal.pmed.1002621
4. Gutierrez KS, LePrevost CE. Climate justice in rural southeastern United States: A review of climate change impacts and effects on human health. *Int J Environ Res Public Health*. 2016;13(2):189. doi:10.3390/ijerph13020189
5. Maxwell J, Blashki G. Teaching about climate change in medical education: An opportunity. *J Public Health Res*. 2016;5(1):673. doi:10.4081/jphr.2016.673
6. Ebi KL, Ogden NH, Semenza JC, Woodward A. Detecting and attributing health burdens to climate change. *Environ Health Perspect*. 2017;125(8):085004. doi:10.1289/EHP1509
7. Rifkin DI, Long MW, Perry MJ. Climate change and sleep: A systematic review of the literature and conceptual framework. *Sleep Med Rev*. 2018;42:3–9. doi:10.1016/j.smrv.2018.07.007
8. Kjellstrom T, Briggs D, Freyberg C, Lemke B, Otto M, Hyatt O. Heat, human performance and occupational health: A key issue for the assessment of global climate change impacts. *Annu Rev Public Health*. 2016;37:97–112. doi:10.1146/annurev-publhealth-032315-021740
9. Glaser J, Lemery J, Rajagopalan B, *et al*. Climate change and the emergent epidemic of CKD from heat stress in rural communities: The case for heat stress nephropathy. *Clin J Am Soc Nephrol*. 2016;11(8):1472–1483. doi:10.2215/CJN.13841215
10. Butler CD, Hanigan IC. Anthropogenic climate change and health in the global south. *Int J Tuberc Lung Dis*. 2019;23(12):1243–1252. doi:10.5588/ijtld.19.0267
11. Kuehn L, McCormick S. Heat Exposure and maternal health in the face of climate change. *Int J Environ Res Public Health*. 2017;14(8):853. doi:10.3390/ijerph14080853
12. Myers SS, Smith MR, Guth S, *et al*. Climate change and global food systems: Potential impacts on food security and undernutrition. *Annu Rev Public Health*. 2017;38:259–277. doi:10.1146/annurev-publhealth-031816-044356
13. Asseng S, Martre P, Maiorano A, *et al*. Climate change impact and adaptation for wheat protein. *Glob Chang Biol*. 2019;25(1):155–173. doi:10.1111/gcb.14481
14. Bayram H, Bauer AK, Abdalati W, *et al*. Environment, global climate change and cardiopulmonary health. *Am J Respir Crit Care Med*. 2017;195(6):718–724. doi:10.1164/rccm.201604-0687PP
15. Rajagopalan S, Al-Kindi SG, Brook RD. Air pollution and cardiovascular disease: JACC state-of-the-art review. *J Am Coll Cardiol*. 2018;72(17):2054–2070. doi:10.1016/j.jacc.2018.07.099
16. Claeys MJ, Rajagopalan S, Nawrot TS, Brook RD. Climate and environmental triggers of acute myocardial infarction. *Eur Heart J*. 2017;38(13):955–960. doi:10.1093/eurheartj/ehw151
17. Schweitzer MD, Calzadilla AS, Salamo O, *et al*. Lung health in era of climate change and dust storms. *Environ Res*. 2018;163:36–42. doi:10.1016/j.envres.2018.02.001
18. Hansel NN, McCormack MC, Kim V. The effects of air pollution and temperature on COPD. COPD. 2016;13(3):372–379. doi:10.3109/15412555.2015.1089846

1. Strosnider H, Kennedy C, Monti M, Yip F. Rural and urban differences in air quality, 2008–2012, and community drinking water quality, 2010–2015 — United States. *MMWR Surveill Summ*. 2017;66(13):1–10. doi:10.15585/mmwr.ss6613a1
2. Liu C, Yavar Z, Sun Q. Cardiovascular response to thermoregulatory challenges. *Am J Physiol Heart Circ Physiol*. 2015;309(11):H1793–H1812. doi:10.1152/ajpheart.00199.2015
3. Pope CA, Muhlestein JB, Anderson JL, *et al*. Short-term exposure to fine particulate matter air pollution is preferentially associated with the risk of ST-segment elevation acute coronary events. *J Am Heart Assoc*. 2015;4(12):e002506. doi:10.1161/JAHA.115.002506
4. McClure CD, Jaffe DA. US particulate matter air quality improves except in wildfire-prone areas. *Proc Natl Acad Sci U S A*. 2018;115(31): 7901–7906. doi:10.1073/pnas.1804353115
5. Reid CE, Maestas MM. Wildfire smoke exposure under climate change: impact on respiratory health of affected communities. *Curr Opin Pulm Med*. 2019;25(2):179–187. doi:10.1097/MCP.0000000000000552
6. Demain JG. Climate Change and the Impact on Respiratory and Allergic Disease: 2018. *Curr Allergy Asthma Rep*. 2018;18(4):22. doi:10.1007/s11882-018-0777-7
7. 25. Poole JA, Barnes CS, Demain JG, et al. Impact of weather and climate change with indoor and outdoor air quality in asthma: A work group report of the AAAAI environmental exposure and respiratory health committee. J Allergy Clin Immunol. 2019;143(5):1702–1710.
8. Katelaris CH, Beggs PJ. Climate change: allergens and allergic diseases. *Intern Med J*. 2018;48(2):129–134. doi:10.1111/imj.13699
9. Ogden NH, Lindsay LR. Effects of climate and climate change on vectors and vector-borne diseases: Ticks are different. *Trends Parasitol*. 2016;32(8):646–656. doi:10.1016/j.pt.2016.04.015
10. Fouque F, Reeder JC. Impact of past and on-going changes on climate and weather on vector-borne diseases transmission: A look at the evidence. *Infect Dis Poverty*. 2019;8(1):51. doi:10.1186/s40249-019-0565-1
11. Caminade C, McIntyre KM, Jones AE. Impact of recent and future climate change on vector-borne diseases. *Ann N Y Acad Sci*. 2019;1436(1): 157–173. doi:10.1111/nyas.13950
12. Butterworth MK, Morin CW, Comrie AC. An analysis of the potential impact of climate change on dengue transmission in the southeastern United States. *Environ Health Perspect*. 2017;125(4):579–585. doi:10.1289/EHP218
13. Levy K, Woster AP, Goldstein RS, Carlton EJ. Untangling the Impacts of Climate Change on Waterborne Diseases: A Systematic Review of Relationships between Diarrheal Diseases and Temperature, Rainfall, Flooding, and Drought. *Environ Sci Technol*. 2016;50(10):4905-4922.
14. Levy K, Smith SM, Carlton EJ. Climate Change Impacts on Waterborne Diseases: Moving Toward Designing Interventions. *Curr Environ Health Rep*. 2018;5(2):272-282. doi:10.1007/s40572-018-0199-7f
15. Trombley J, Chalupka S, Anderko L. Climate Change and Mental Health. *Am J Nurs*. 2017;117(4):44-52. doi:10.1097/01.NAJ.0000515232.51795.fa
16. Veenema TG, Thornton CP, Lavin RP, Bender AK, Seal S, Corley A. Climate Change-Related Water Disasters' Impact on Population Health. *J Nurs Scholarsh*. 2017;49(6):625-634. doi:10.1111/jnu.12328
17. Hayes K, Blashki G, Wiseman J, Burke S, Reifels L. Climate change and mental health: risks, impacts and priority actions. *Int J Ment Health Syst*. 2018;12:28. Published 2018 Jun 1. doi:10.1186/s13033-018-0210-6
18. Obradovich N, Migliorini R, Paulus MP, Rahwan I. Empirical evidence of mental health risks posed by climate change. *Proc Natl Acad Sci U S A*. 2018;115(43):10953-10958. doi:10.1073/pnas.1801528115
19. Burke SEL, Sanson AV, Van Hoorn J. The Psychological Effects of Climate Change on Children. *Curr Psychiatry Rep*. 2018;20(5):35. Published 2018 Apr 11. doi:10.1007/s11920-018-0896-9
20. Wellbery CE. Climate Change Health Impacts: A Role for the Family Physician. *Am Fam Physician*. 2019;100(10):602-603.
21. Boland TM, Temte JL. Family Medicine Patient and Physician Attitudes Toward Climate Change and Health in Wisconsin. *Wilderness Environ Med*. 2019;30(4):386-393. doi:10.1016/j.wem.2019.08.005
22. Valois P, Blouin P, Ouellet C, Renaud JS, Bélanger D, Gosselin P. The Health Impacts of Climate Change: A Continuing Medical Education Needs Assessment Framework. *J Contin Educ Health Prof*. 2016;36(3):218-225. doi:10.1097/CEH.0000000000000084
23. Parker CL, Wellbery CE, Mueller M. The Changing Climate: Managing Health Impacts. *Am Fam Physician*. 2019;100(10):618-626.
24. Glaser J, Lemery J, Rajagopalan B, *et al*. Climate Change and the Emergent Epidemic of CKD from Heat Stress in Rural Communities: The Case for Heat Stress Nephropathy. *Clin J Am Soc Nephrol*. 2016;11(8):1472-1483. doi:10.2215/CJN.13841215

CLINICAL IMAGE

PERSISTENT RED EYE IN A PATIENT WITH IGA NEPHROPATHY

Leonid Skorin, Jr., DO, OD, MS, FAAO, FAOCO[1]; Lucas J. Asfeld, OD[2]; Ragna Godtland, OD, FAAO[1]

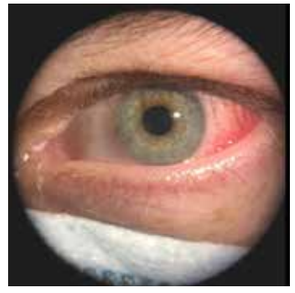
[1]Mayo Clinic Health System, Albert Lea, MN
[2]Pacific University College of Optometry, Forest Grove, OR

A 37-year-old man reported to the eye clinic with irritation and pain on eye movement in his left eye for 15 days. He had associated symptoms of foreign body sensation, grittiness, itching and mild headaches. The patient reported no specific events or activities associated with the onset of his ocular symptoms, and neither fever nor recent illness were noted. Medical history included hypertriglyceridemia, obstructive sleep apnea, obesity, hyperglycemia, hypothyroidism, hypertension and gout. He also had Berger's disease—immunoglobin A nephropathy (IgA nephropathy)—resulting in stage 4 chronic kidney disease for which he was on dialysis and awaiting a kidney transplant. Five days earlier, he was seen by his optometrist who prescribed topical prednisolone acetate 1% every hour while awake for his left eye. During his current visit, he reported minimal improvement with the topical steroid therapy.

His visual acuities at this visit were 20/20 in each eye and his intraocular pressures were 21 mm Hg OD and 22 mm Hg OS. Pupils were equal, round, reactive, with no afferent pupillary defect found. Motility was normal with no restrictions. There was no proptosis, and his eyelids were normal. Anterior segment examination, with a slit lamp, of the left eye revealed 2+ temporal bulbar conjunctival injection, trace conjunctival chemosis and no staining of the cornea or conjunctiva with fluorescein dye. His left eye had no cells or flare in the anterior chamber, and his right eye was unremarkable. The posterior segment of both eyes was healthy.

FIGURE 1:

Primary gaze anterior segment photograph of the left eye showing injection of the temporal deep scleral vessels and bulbar conjunctival chemosis.

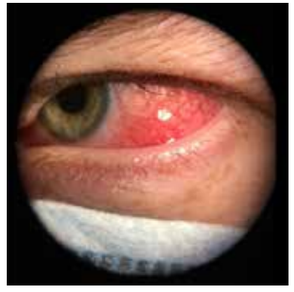


CORRESPONDENCE:
Leonid Skorin, Jr., DO, OD, MS, FAAO, FAOCO | skorin.leonid@mayo.edu

 Print ISSN: 1877-573X
doi:10.33181/13081

FIGURE 2:

Right gaze anterior segment photograph of the left eye showing injection of the temporal deep scleral vessels and bulbar conjunctival chemosis.



QUESTIONS

1. What is the most likely ocular diagnosis?

a. Foreign body

b. Corneal abrasion

c. Scleritis

d. Orbital cellulitis

2. What is the next best treatment plan for the most likely diagnosis?

a. Start oral nonsteroidal anti-inflammatory drugs (NSAIDs)

b. Start oral steroids

c. Start oral antibiotics

d. Start steroid-sparing immunosuppressive therapy

ANSWERS:

1. What is the most likely ocular diagnosis?

Correct Answer:
C) Scleritis

Scleritis is an ocular inflammatory condition of the sclera, often associated with an underlying systemic etiology. It can result in severe eye pain, pain on eye movement, pain of the areas surrounding the orbit, lacrimation, photophobia and potential vision loss.[1] Common signs include edema, dilation of deep scleral vessels, corneal infiltrates, corneal thinning, stromal keratitis and trabeculitis.[1] Corneal or conjunctival foreign body and corneal abrasion are the two most common forms of ocular trauma.[2]

Typically these result from lack of eye protection during high-risk activities.[2] They can present as blurred vision, redness, tearing, photophobia, extreme discomfort with or without the eyes closed and a feeling of something in the eye. Foreign body and corneal abrasion were ruled out due to the lack of any associated high-risk activity and no corneal or conjunctival staining with fluorescein dye installation. Orbital cellulitis is an infection of the soft tissue surrounding the eye that can cause conjunctival injection and severe ocular pain, especially on eye movement. However, other signs, such as fever, proptosis, restricted ocular movements, increased intraocular pressure and swelling or erythema of the eyelids, are often present as well.[3]

2. What is the next best treatment plan for the most likely diagnosis?

Correct Answer:
B) Start oral steroids

Management of anterior scleritis is largely based on the clinical presentation, severity, associated systemic conditions, and risk factors of treatment. However, the available treatment options can have severe side effects. Although topical administration of corticosteroids has limited success, it can be considered as a first line treatment of mild scleritis to reduce potential risks of systemic medications.[4] Oral NSAIDs are also considered first tier treatment for non-infectious scleritis and can be used if topicals fail.[4] For some patients, additional treatment beyond NSAIDs is needed. Second line treatment of scleritis can include oral corticosteroids and even subconjunctival corticosteroid injections if orals are unsuccessful.[4] When anterior non-infectious scleritis becomes severe, or oral steroid treatment has failed, immunosuppressive agents such as methotrexate may be used.[4] Research has shown biologics to be beneficial in scleritis as a last line treatment when all other treatments have failed. [4]

For this patient, oral NSAIDs would be contraindicated due to the association of increased mortality in patients taking oral NSAIDs while on dialysis.[5] In general, NSAIDs should be avoided in patients with kidney disease.[6] Due to lack of resolution with topical steroids, and the contraindication of NSAIDs, the next treatment option for our patient would be oral corticosteroids. Oral antibiotics would not be indicated since the patient was afebrile and there was no sign of an infectious cause. Due to this patient's mild presentation, steroid-sparing immunosuppressive therapy would not be necessary at this stage.

DISCUSSION

The incidence and prevalence of scleritis is found to be 3.4 and 5.2 per 100,000 person-years respectively.[7] Scleritis can be caused by systemic autoimmune conditions, infection, ocular surgery, trauma, chemical injury, and infiltrating ocular neoplasms.[8] Although this condition may be idiopathic, up to 50% of the time it is associated with an underlying systemic disease.[1,9] Associated systemic diseases can include rheumatoid arthritis, granulomatosis with polyangiitis, polyarteritis nodosa, spondyloarthropathies, IgA nephropathy and sarcoidosis.[1,8,9] Typically the systemic diagnosis is present prior to the onset of the associated ocular findings.[9] In the absence of a known systemic condition, lab work is indicated. However, systemic therapy is often needed whether a systemic association is present or not.[9]

In this case, the associated systemic disease was found to be IgA nephropathy, also known as Berger's disease. It is an accumulation of immunoglobulin A inside the glomeruli of the kidney. Patients can be asymptomatic, present with hematuria or proteinuria, or have reduced kidney function due to inflammation and fibrosis.[10] Our patient was diagnosed with IgA nephropathy after suffering a hypertensive emergency and acute kidney injury 1 year prior. Diagnosis of IgA nephropathy typically includes renal biopsy, which was the case in our patient. The patient then suffered acute renal failure, was put on dialysis 3 times per week and was placed on the kidney transplant list.

In a study of 116 patients with primary glomerular diseases, 6 out of 39 patients with IgA nephropathy presented with episcleritis or deep scleritis.[11] Scleritis was not found in any of the other six types of primary glomerular disease discussed in the study.[11] From this study it was thought that the deposits within the glomeruli and the accompanying scleritis could be the result of the IgA-associated immune complexes.[11]

The patient's medical history also included gout, which is a systemic condition occasionally associated with scleritis.[12] However, the patient was taking a maintenance dose of 200 mg allopurinol daily and was completely asymptomatic of any recent gout attacks. For this reason, gout was clinically ruled out as the underlying cause of the patient's scleritis.

PATIENT OUTCOME

Treatment was coordinated with the patient's primary care physician, and he was started on 60 mg daily of oral prednisone for 14 days. The patient returned to the eye clinic two weeks later with complete resolution of pain and only mild redness. Visual acuities were 20/20 in both eyes and the anterior segment findings were normal with only 1+ injection in the left eye remaining. His intraocular pressures were 19 mm Hg OD and 20 mm Hg OS. The 14-day oral prednisone treatment was completed, tapered to 50 mg daily for one week, and the patient was scheduled for follow up with his primary care physician.

REFERENCES:

1. Okhravi N, Odufuwa B, McCluskey P, Lightman S. Scleritis. *Surv Ophthalmol*. 2005;50(4):351-363. doi:10.1016/j.survophthal.2005.04.001
2. Camodeca AJ, Anderson EP. Corneal Foreign Body. In: *StatPearls*. *StatPearls* Publishing; August 10, 2020.
3. Armstrong PA, Nichol NM. An eye for trouble: Orbital cellulitis. *Emerg Med J*. 2006;23(12):e66. doi:10.1136/emj.2006.041194
4. Lagina A, Ramphul K. Scleritis. In: *StatPearls*. StatPearls Publishing; October 12, 2021. https://www.ncbi.nlm.nih.gov/books/NBK499944/
5. Lai KM, Chen TL, Chang CC, Chen HH, Lee YW. Association between NSAID use and mortality risk in patients with end-stage renal disease: a population-based cohort study. *Clin Epidemiol*. 2019;11:429–441. doi:10.2147/CLEP.S204322
6. Williams AW, Dwyer AC, Eddy AA, *et al*. Critical and honest conversations: the evidence behind the 'Choosing Wisely' campaign recommendations by the American Society of Nephrology. *Clin J Am Soc Nephrol*. 2012;7(10):1664–1672. doi:10.2215/CJN.04970512

7. Honik G, Wong IG, Gritz DC. Incidence and prevalence of episcleritis and scleritis in Northern California. *Cornea*. 2013;32(12):1562–1566. doi:10.1097/ICO.0b013e3182a407c3
8. McCluskey P, Wakefield D. Current concepts in the management of scleritis. *Aust N Z J Ophthalmol*. 1988;16(3):169–176. doi:10.1111/j.1442-9071.1988.tb01206.x
9. Raiji VR, Palestine AG, Parver DL. Scleritis and systemic disease association in a community-based referral practice. *Am J Ophthalmol*. 2009;148(6):946–950. doi:10.1016/j.ajo.2009.07.021
10. Rodrigues JC, Haas M, Reich HN. IgA nephropathy. *Clin J Am Soc Nephrol*. 2017;12(4):677–686. doi:10.2215/CJN.07420716
11. Nomoto Y, Sakai H, Endoh M, Tomino Y. Scleritis and IgA nephropathy. *Arch Intern Med*. 1980;140(6):783–785. PMID: 7387272
12. Ao J, Goldblatt F, Casson R. Review of the ophthalmic manifestations of gout and uric acid crystal deposition. *Clin Exp Ophthalmol*. 2016;45(1):73–80. doi:10.1111/ceo.12749

PATIENT EDUCATION HANDOUT

acofp AMERICAN COLLEGE OF OSTEOPATHIC FAMILY PHYSICIANS

Low-Back Pain in Adolescents

Puneet Tung, DO, FAAP
Paula Gregory, DO, MBA, FACOFP, Editor • Lindsay Tjiattas-Saleski, DO, MBA, FACOEP, Health Literacy Editor

Low-back pain is a common reason for some children and adolescents to see their doctor. The risk for low-back pain increases with increasing age, puberty and growth. At least 7% of 12-year-olds have had at least 1 episode of low-back pain. By age 20, the lifetime prevalence of low-back pain has been reported as high as 80%. Having low-back pain as a teenager is predictive of having low-back pain as an adult.

Most back pain in adolescents is benign and usually caused by musculoskeletal conditions, such as strains or sprains. Some adolescents have had an injury or have serious underlying medical conditions that cause their low-back pain. Eighty percent of adolescent low-back pain does not have a specific cause and may be due to many different things.

Risk factors for having low-back pain include a family history of low-back pain, a previous back injury, time spent sitting, sports participation and female gender. Teenagers who do not participate in any physical activity are more likely to have low-back pain compared to teenagers who are more active. However, those who are very active in sports, especially very competitive sports, are more likely than sedentary individuals to have low-back pain. A lot of parents worry that a heavy backpack will cause low-back pain, but several studies have concluded that this is not true.

Your doctor should perform a comprehensive history and physical on your teenager during their visit. They should also look for warning signs that the low-back pain may be due to something more serious. Pain that wakens your child from sleep, pain that is sudden, pain that lasts longer than four weeks, fever, weight loss, tenderness over the spine, or any abnormal neurological findings like numbness or tingling need medical attention right away.

There are many ways to help your child or teenager if they are having low-back pain. It is important to let your child rest and avoid activities that make their low-back pain worse. Applying ice in the first 24 hours can help them feel better, after which a heating pad will help. Using over-the-counter medicines, like ibuprofen, can help with their pain and muscle inflammation. Their doctor may also refer them to physical therapy if the back pain is due to muscle weakness. Physical therapy focuses on increasing muscle strength and flexibility. Osteopathic manipulative treatment has also been shown to improve muscle function and movement in this population.

SOURCE(S):

1. Back pain in children. OrthoKids: Pediatric Orthopaedic Society of North America. https://orthokids.org/en-US/Condition/Back-Pain-in-Children
2. Back pain in children & teens. HealthyChildren.org. Updated May 17, 2016. https://www.healthychildren.org/English/health-issues/conditions/orthopedic/Pages/Back-Pain-in-Children-Teens.aspx
3. Nigrovic P. Patient education: back pain in children and adolescents (beyond the basics). Uptodate.com. Updated August 2, 2021. https://www.uptodate.com/contents/back-painin-children-and-adolescents-beyond-the-basics

Expand your digital skills and discover new opportunities.

See how new, patient-centered approaches to evaluating digital health products can lead to safe, effective, equitable and ethical patient care with Digital Health for Practicing Clinicians: A Certificate Program.

Earn 5.00 AOA Category 1-A CME credits with successful completion of these eight modules:

- Introduction to Digital Health
- Evaluative Frameworks for Selecting Technology for Patients and Clinics
- Best Practices for Telemedicine
- Artificial Intelligence in Healthcare
- Integrating Digital Health Technologies into Clinical Care
- Patient Advocacy in Digital Health
- Consumer Health Informatics
- Health Equity and Ethics in the Digital Age

Learn more: acofp.org/digitalhealth

DIGITAL MEDICINE SOCIETY

acofp | AMERICAN COLLEGE OF OSTEOPATHIC FAMILY PHYSICIANS

ROCKY VISTA UNIVERSITY

Adam Feingertz
732-890-3358
afeingertz@merchantadvocate.com

MERCHANT ADVOCATE™
merchantadvocate.com

American College of Osteopathic Family Physicians
330 East Algonquin Road, Suite 1
Arlington Heights, IL 60005

Non-Profit Org.
U.S. Postage
PAID
Carol Stream, IL
PERMIT NO.
1746