

# Concussion—Mild Traumatic Brain Injury Recoverable Injury with Potential for Serious Sequelae



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## KEYWORDS

• Concussion • Mild TBI • Sequelae of concussion

## KEY POINTS

- Concussion is a clinical syndrome induced by biomechanical force causing neurologic symptoms that recover in most individuals.
- A minority of patients with concussion go on to develop persistent symptoms that may be disabling.
- Proper management of concussion includes protecting the individual from repeated injury, assessment for risk factors or comorbidities that may prolong recovery, symptomatic care, reassurance, initial rest, and providing a planned gradual return to cognitive and physical demand.
- Remote deficits from mild traumatic brain injury include motor, cognitive, and endocrine dysfunction and potential neurodegeneration, for which the mechanisms are still being elucidated.

## INTRODUCTION

Although the original contemplation of concussion originated in Ancient Greece (**Fig. 1**),<sup>1</sup> public and scientific awareness are finally gaining traction. The scientific establishment now recognizes that the consequences of mild traumatic brain injury (mTBI) might not always be so mild. With ongoing development of basic and clinical science, it becomes possible to provide better prevention, assessment, and treatment for concussions, particularly in higher-risk groups like military personnel, athletes, and pediatric patients.

## DEFINITIONS

In order to proceed with a discussion of mTBI and concussion, one must establish working definitions, because mTBI and concussion are often used interchangeably. As seen in **Table 1**, mTBI is historically based on Glasgow Coma Score (GCS), whereas concussion is a clinical syndrome that may overlap with mild, moderate, and severe TBI.

## EPIDEMIOLOGY

Whether from increased awareness or an increased risk, the rate of reported TBI in the United

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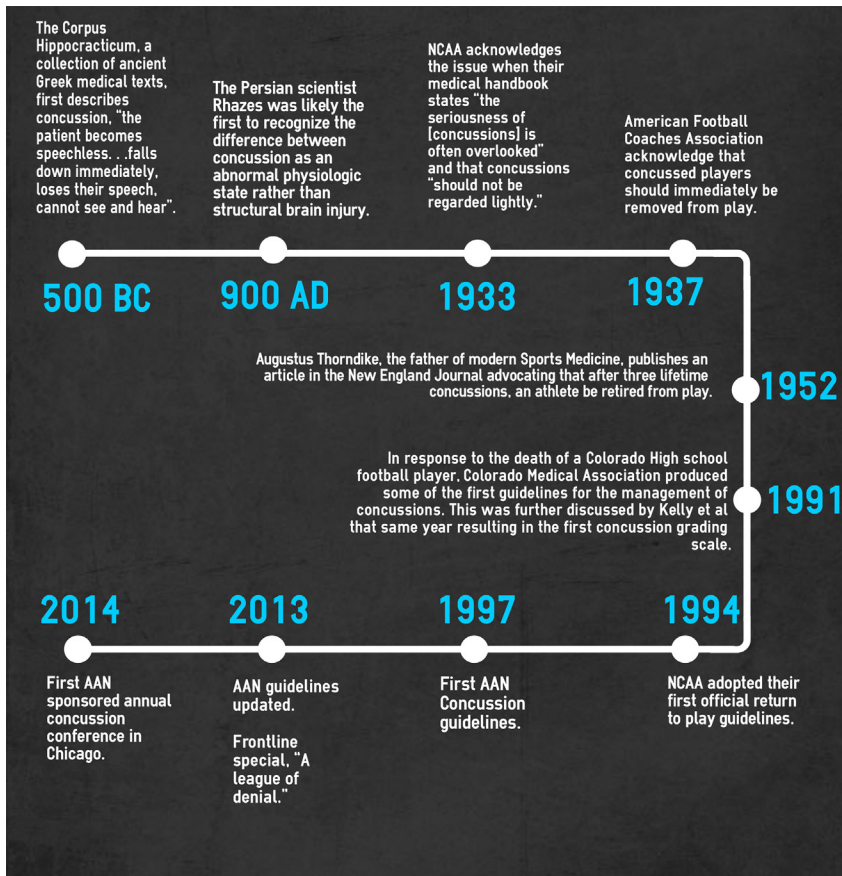


Fig. 1. History of concussions.

States has been increasing. From 2001 to 2009, the number of annual TBI-related emergency department (ED) visits related to sports and recreation activities increased from 153,375 to 248,418, with the highest rates among young men aged 10 to 19.<sup>2</sup> However, the ED is just the tip of the iceberg, because it is estimated that there are greater than 700,000 mTBIs per year in high school athletes alone, and more than 13% of these are in patients with recurrent concussions.<sup>3</sup>

Sports-related concussions have been on the increase, likely due to both increased recognition and increased power and strength in our athletes. In 2007, Hootman and colleagues<sup>4</sup> analyzed National Collegiate Athletic Association (NCAA) data from 1988 to 2004 regarding all injuries, including concussion. There was no significant change in overall rate of injury; however, concussions did increase significantly over this interval. Surprisingly, women's soccer had the highest risk of concussion per 1000 athlete exposures with a rate of 0.41, which was not only higher than men's soccer at 0.28, but on par with men's football's risk of 0.37.

This finding brought the idea to the forefront that women not only are at risk of concussion but may even be at a higher risk within the same activity compared with their male counterparts. Many theories have been proposed to explain this discrepancy, including hormonal differences, weaker neck muscles, and higher rate of symptom reporting among female athletes. Multiple investigators have confirmed that among comparable sports, in which rules of play are similar, women have a higher rate of concussions.<sup>5,6</sup>

## PATHOPHYSIOLOGY

Concussion is a complicated syndrome of microstructural injury and functional impairment.<sup>7,8</sup> The initial event after impact is dominated by a massive flux of ions and excitatory neurotransmitters, resulting in a metabolic crisis. Rat models show that after fluid percussion injury (FPI), ionic flux of sodium, potassium, and calcium occurs, concomitant with a release of excitatory neurotransmitters, predominantly glutamate. Glutamate

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