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White Matter: Structural and Functional Roles in Health and Disease

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Abstract

This article reviewed the literature regarding structural and functional roles of white matter in health and disease. It was found that white matter has a structure consisting of bundles that work to connect areas of gray matter in the brain. These bundles also transmit nerve impulses between neurons. Myelin, the outer coating envelop acts as an insulator and permits the jumping of electrical signals instead of passing through the axon. From a functional point of view, white matter carries the messages among various areas of gray matter through the central nervous system. The white matter is called white due to the presence of the fatty material (myelin) that makes the outer layer of axons, and accelerates the transmission of nerve signals. We showed the impacts of alcohol use and other diseases such as Alzheimer disease on white matter. Taken together, white matter has central roles in health and disease.

Keywords: White matter, myelin, alcohol, Alzheimer disease, axon.

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INTRODUCTION

The white matter is composed of fibers with ascending and descending orientation that are either originating in or projecting to the cortex (Zola-Morgan, 1995; Jiang *et al.,* 2017). White matter is consisted of bundles that work to connect areas of gray matter in the brain. These bundles also transmit nerve impulses between neurons (O'Muircheartaigh and Jbabdi, 2018). Myelin, the outer coating envelop acts as an insulator and permits the jumping of electrical signals instead of passing through the axon (Klein and Thorne, 2007; Fields, 2014). The volume of white matter in women is generally less than that in males in either terms of volume and myelinated axons. As age increases, white matter volume decreases (Lisbeth *et al.,* 2003; Kanaan *et al.,* 2012).

White matter carries the messages among various areas of gray matter through the central nervous system. The white matter is called white due to the presence of the fatty material (myelin) that makes the outer layer of axons, and accelerates the transmission of nerve signals (Colby, 2012). The development of white matter continues and reaches its peak in middle age (Lisbeth *et al.,* 2003, McEvoy *et al.,* 2018). A very well- known example illustrating the effects of disease on white matter is multiple sclerosis (MS) in which the myelin surrounding the axon is damaged by inflammatory processes (Kim *et al.,* 2006; Klawiter *et al.,* 2011). The use of alcohol leads to disorders that are accompanied with decreased white matter volume (Monnig *et al.,* 2013). Evidence from studies on animals demonstrated that alcohol induced the volume of white matter through breaking down oligodendrocytes that act to keep myelin (Alfonso-Loeches et al., 2012).

Some changes may occur in white matter, known as amyloid plaques are associated with Alzheimer’s disease besides other neurodegenerative diseases (Albert *et al.,* 2011). The injuries affecting white matter may be reversible (Kinnunen *et al.,* 2011). A group of changes are usually occurred in white matter with age such as leukoaraiosis are likely to occur as a result of various conditions including loss of myelin, axonal loss, and a breakdown of the blood – brain barrier (Gupta *et al.,* 2012).

Neuroimaging can be used to detect the volume changes in white matter. Diffusion tensor imaging (DTI) was used to investigate changes in the volume of white matter under the effect of learning a new motor task (e.g. juggling) (Scholz *et al.,* 2009). It was demonstrated for the first time that motor learning is associated with changes of white matter. Another study by Sampaio-Baptista (2013) showed that changes in white matter associated with motor learning are due to increase in myelinations.

CONCLUSION

White matter has important structural and functional roles in health and disease and may have future therapeutic implications.

CONFLICT OF INTEREST

All the authors have declared that no conflict of interest exists.

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