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Yawning as a Potential Diagnostic Indicator for Underlying Neurological Disorders

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Abstract

Yawning has fascinated researchers and clinicians for centuries but has been controversial and illusive in respect of its origin, mechanism and usefulness as a predictor of disease. With the advent of brain scanning techniques and an increased understanding of metabolism and neural pathways, a better understanding of the variance of yawning and possible associated pathways has been achieved. Knowledge about yawning has reached a level of sophistication that makes it possible to be a predictor of underlying neurological disease and health problems. Although there is still considerable inconsistency and lack of consensus amongst researchers, several hypotheses have emerged that make the topic worthwhile to pursue with a view to obtaining a potential diagnostic tool for health problems.

Keywords: ***Diagnosis in neurological rehabilitation; Diagnostic indicator; Neurological rehabilitation; Underlying neurological problems; Yawning***

1. Introduction

Over many centuries various reports on yawning have emerged. As far back as 400 BC, the famous philosopher Hippocrates claimed that yawning usually precedes a high body temperature and, similar to a large quantity of water achieving boiling point, the accumulated air in the lungs reaches a crescendo before opening the mouth to release the air [1]. This rather intriguing and simplistic view has since found identity amongst animal researchers who have declared a thermoregulatory hypothesis of yawning [2].

Subsequent clinical evidence has found a link between rises in body temperature and episodes of yawning in people with incomplete innervation such as multiple sclerosis [3,4]. Temperature lowering seems to occur following excessive yawning probably because the air is released followed by feedback that signals the hypothalamus to regulate body temperature [5].

The Thompson Cortisol Hypothesis [6,7] has proposed and shown evidence of the critical role of cortisol released by stimulation of the hypothalamus [8]. Corticotrophin-releasing hormone (CRH) released from the hypothalamus stimulates the anterior pituitary to then release adrenocorticotropic hormone (ACTH). This hormone acts on the adrenal cortex to release cortisol. The increase in blood cortisol levels signals the hypothalamus to reduce or stop further release of CRH through the feedback system [9]. Known as the H-P-A axis, the hypothalamus-pituitary-adrenal axis is important for protecting the body against infection and stress because antigens are also released by the adrenal glands when they are stimulated by ACTH [10].

2. Fatigue and Yawning

As well as temperature fluctuations being observed in incompletely innervated individuals, fatigue has been commonly reported [11]. Particularly in people with immune suppression [2], fatigue is an important factor in recovery from symptomatic episodes of relapsing multiple sclerosis and in coping with activities of everyday living [9].

People who have suffered an ischaemic brain stem stroke have been reported in the context of yawning where the phenomenon *parakinesia brachialis oscitans* (PBO) sees an involuntary upward movement of the paralysed arm during yawning [12]. This is perhaps the origin of the curious and enigmatic fictitious character in Stanley Kubrick's 1964 film *Dr Strange Love* who has an arm that is apparently under involuntary control [13].

3. Contagious Yawning

Contagious yawning, when yawning is triggered by the yawns of others, is considered to be a recent phenomenon in terms of human evolution [14]. Norscia et al. [14] predicted that pregnant women would be more likely to contagiously yawn than nonpregnant, nulliparous women (i.e., who had not given live birth). The researchers suggested that yawning in highly social species such as humans might be utilised for emotional contagion during evolution as they found that pregnant women were more likely to be susceptible to contagious yawning.

The mirror neuron system has also been postulated as an explanation of contagious yawning [15]. Empathy may play an important role in the elicitation of yawning contagion [16]. Facial mimicry and yawn contagion seem to share some of the brain areas during action including the ventromedial prefrontal cortex, superior temporal sulcus and the amygdala [17]. Researchers have increasingly focused on explanations from neuroanatomy including the use of MRI brain scanning techniques to reveal links between anatomical structures and feedback mechanisms [18]. Such associations have been found with the motor cortex and hypothalamus [19,20].

It is interesting to note that human infants seem not to show contagious yawning [21] but it is unclear whether they perceive yawning in the same manner as other emotional expressions and differently to adults. However, preschool children aged between 2.5 and 5.5 years do appear to show the effects of contagious yawning [22].

4. Frequent Yawning as a Diagnostic Indicator

Repetitive yawning can be another factor of note when diagnosing underlying neurological conditions. Premortem yawning has been reported consistently in association with acute infections and haemorrhage including the Bubonic Plague [23,24]. Vasovagal reflex, intracranial hypertension, hypoglycaemia, anaemia, and hypoxia have all been associated with repetitive yawning [25-27].

Probable cause of yawning with shock may be a decrease of the central nervous system's (CNS) adenosine triphosphate production causing CNS tissue hypoxia and leading to an excess of glutamate within the paraventricular nucleus. In turn, yawning, hypotension and bradycardia is activated [28].

The yawning research team at the Universities of Bournemouth, United Kingdom and Paris Ouest Nanterre La Défense, France led by Professor Dr Simon B N Thompson, have been the first to describe the 'yawning envelope' which is an electromyographical profile of the yawn as it is being elicited [7]. The yawning envelope is a capture or snap shot of the yawn episode [6]. The researchers have observed association with fatigue, the yawn envelope (and electromyographical changes during the yawn) and changes in the level of cortisol [29].

Brown et al. [30] found an increased excitability of the cells of the primary cortex in humans which gives support to the suggestion that there are specific cortisol receptors in the motor cortex [10,31] and that these communicate with the hypothalamus providing essential feedback for the regulation of cortisol via the H-P-A axis.

Whilst others have shown involvement of the dorsolateral prefrontal cortex region in preparing and maintaining the state of alertness in individuals during phasic alertness tasks [32], Anglo-French teams have tested intrinsic and phasic fatigue in paradigms that demonstrate association with fatigue and changes in cortisol levels [18]. This helps towards an explanation of the frequently observed fatigue in people with immune suppression such as multiple sclerosis[11] where rises in cortisol levels have been associated with fatigue and yawning [9].

5. Conclusion

Expansion of the Thompson Cortisol Hypothesis [11] purports a threshold level of cortisol and possibly also cerebrospinal fluid [33], is necessary for an episode of yawning to occur. Communication between the motor cortex and hypothalamus as seen in MRI studies of yawning [18] suggest that the motor cortex is implicated in the regulation of cortisol as well as previously known structures such as those dedicated to the H-P-A axis.

Combining findings from past work on ischaemic stroke and PBO and those of intrinsic and phasic alertness task studies, helps us better understand the importance of the functional role of the brain stem in the regulation of fatigue, stress and yawning. Using these data may well contribute towards a further step in developing a consistent diagnosis for protracted and disruptive immunosuppression diseases such as multiple sclerosis in the near future.

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