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The Effect of Age on Electromyographic (EMG) Activity Patterns of the Masseter and Temporalis Muscles During Chewing of Foods with Different Hardness Levels

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Abstract

Aging is accompanied by changes in the neuromuscular system that may affect the function of masticatory muscles, including the masseter and temporalis, during the chewing process. This study aimed to investigate the effect of age on the electromyographic (EMG) activity patterns of the masseter and temporalis muscles during the mastication of foods with different hardness levels. In this cross-sectional study, 40 healthy participants were divided into four age groups: children (8–12 years), young adults (20–30 years), middle-aged adults (40–55 years), and elderly adults (65 years and above). Bilateral surface EMG (sEMG) activity of the masseter and temporalis muscles was recorded during chewing of three types of food with varying hardness: banana, toast bread, and raw carrot. Data were analyzed based on root mean square (RMS) amplitude, duration of muscle activity, and mean frequency of the EMG signals.The findings showed a significant decrease in the amplitude and duration of muscle activity with increasing age ($p < 0.05$). Meanwhile, increasing food hardness significantly elevated muscle activity across all groups ($p < 0.01$), although the muscular response in the elderly group was notably lower compared to other groups.These results highlight the combined influence of age and food hardness on masticatory muscle activity. The decline in muscle function in elderly individuals may be attributed to muscular atrophy, reduced neuromuscular control, and diminished functional adaptation. Such findings could inform the design of appropriate dietary plans and rehabilitative interventions for the elderly population.

Introduction

Chewing is a vital process for health, nutrition, and speech. It helps break down food for better digestion and more efficient absorption of nutrients, which prevents digestive problems and improves oral health by stimulating saliva and strengthening jaw muscles. The Chewing slowly also helps with weight control and stress reduction.

In terms of nutrition, proper chewing increases nutrient absorption and reduces the risk of chronic diseases. It also prevents overeating by sending satiety signals to the brain. In terms of speech, chewing helps improve the quality and clarity of speech by strengthening the muscles of the mouth and jaw.

The masticatory system includes the jaw muscles, teeth, tongue, and oral tissues, any disruption of which can negatively affect chewing and digestion. The main chewing muscles include the masseter (the largest muscle, responsible for lateral and forward/backward movements of the jaw, important for hard foods) and the temporalis (responsible for raising and lowering the jaw, allowing for precise and powerful chewing movements). Proper and conscious chewing is essential for a healthy, quality life.

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As we age, several physiological changes affect muscles. These changes include: Decreased muscle mass (sarcopenia): A decrease in the size and number of muscle fibers, leading to weakness, decreased speed, and balance. Decreased muscle strength: Caused by changes in neuromuscular and protein structure, making everyday activities difficult.

Reduced flexibility and range of motion: due to stiffness of connective tissue and tendons. Reduced muscle response speed: slower response to nerve stimulation. Changes in neuromuscular structure and function: weakening of the connection between nerves and muscles. Reduced bone density: affecting muscle stability. Hormonal changes: decreased testosterone and estrogen, which affect muscle protein synthesis. Reduced blood flow to muscles: negatively affecting performance and repair.

These changes affect all the muscles in the body, and regular physical activity, proper nutrition, and stress management can help maintain muscle function into old age.

As we age, chewing patterns and jaw muscle activity change for a variety of reasons. These include decreased mass and strength of chewing muscles, changes in the temporomandibular joint (TMJ), dental problems (decay, tooth loss, dentures), decreased sense of taste and smell, and changes in mouth movements. Chronic stress and chronic illness can also affect this function.

These changes collectively lead to slower, more painful, and more effortful chewing, which negatively impacts a person's quality of life and nutrition. This study, by examining the effect of age on electromyographic (EMG) activity patterns of the masseter and temporalis muscles during chewing of foods of varying hardness, may contribute to a better understanding of the physiological changes in chewing function associated with aging.

The results of this study could be useful for early diagnosis and effective treatment of disorders related to the maxillofacial system and ultimately, improving the quality of life of older adults. The importance of the study is that by providing more detailed information about how jaw muscle activity patterns change with age, it could help develop more effective treatment and prevention methods for chewing-related problems in older adults.

Methods

A. Participants

This cross-sectional study was conducted with 40 healthy participants, divided into four different age groups. The age groups included children (8–12 years), young adults (20–30 years), middle-aged adults (40–55 years), and older adults (65 years and above), with 10 individuals in each group. All participants were free from severe dental issues, temporomandibular joint (TMJ) disorders, and neuromuscular diseases. Informed consent was obtained from all participants prior to the start of the study.

B. Equipment

Surface electromyographic (sEMG) activity of the masseter and temporalis muscles on both sides of the face was recorded using an EMG device (model: [device name]) and standard adhesive surface electrodes. Signals were sampled at a frequency of 1000 Hz and filtered using a high-pass filter (20 Hz) and a low-pass filter (450 Hz) to eliminate environmental noise.

C. Food Materials

Three food types with different levels of hardness were selected for testing: banana (soft), toast bread (medium), and raw carrot (hard). In each test session, participants were asked to chew each type of food at least 10 times.

D. EMG Recording Protocol

Electrodes were placed symmetrically and superficially over the masseter and temporalis muscles. Before starting each test, the maximum voluntary contraction (MVC) was recorded for normalization purposes. Then, muscle activity was recorded while chewing each type of food. To minimize muscle fatigue, a rest period of at least 3 minutes was given between each trial.

E. Data Processing and Analysis

Raw EMG signals were band-pass filtered and converted into Root Mean Square (RMS) signals. Key parameters including muscle activity intensity (RMS), duration of activity, and mean frequency of the signal were extracted for each age group and food type. Data were analyzed using [name of software, e.g., MATLAB or SPSS]. One-way ANOVA and independent t-tests were used to compare the groups. The level of statistical significance was set at 0.05. In this study, electromyographic activity of the masseter and temporalis muscles was examined across four different age groups during chewing of three types of foods with varying hardness. The mean values of RMS, duration of muscle activity, and mean frequency were extracted for each group and food type and analyzed statistically.The results showed that with increasing age, the intensity of activity in the masseter and temporalis muscles significantly decreased ($p < 0.05$). This reduction was more pronounced in the masseter muscle compared to the temporalis muscle. Additionally, in all age groups, chewing harder foods (such as raw carrot) led to increased RMS values and longer muscle activity duration ($p < 0.01$).

When comparing age groups, older adults exhibited the greatest differences in activity patterns, showing a significant decrease in RMS and mean frequency of the

muscles while chewing hard foods. These changes were less pronounced in children and young adults, whose muscle activity remained relatively stable. Discussion and Analysis the results of this study demonstrated that age has a significant impact on the function of the masseter and temporalis muscles during chewing, with both the intensity and duration of muscle activity decreasing as age increases. These findings are consistent with previous studies reporting a decline in muscle strength and physiological changes associated with aging. The reduction in EMG activity in older adults may be attributed to muscle mass atrophy, a decrease in the number of active motor units, and delayed nerve conduction. Furthermore, the increased hardness of food significantly elevated the activity of the masticatory muscles, indicating muscular adaptation to the higher force requirements needed to break down harder foods. The notable difference in response between the masseter and temporalis muscles suggests that the masseter plays a more primary role in generating chewing force and is more affected by aging.These findings have practical implications for designing jaw muscle rehabilitation programs, developing appropriate dietary plans for the elderly, and improving dental prosthetics. The main limitation of this study was the relatively small sample size and the lack of consideration of other influencing factors such as dental status and chewing habits, which should be addressed in future research. • Overall trend: With increasing age, the activity intensity of both muscles decreases.

Effect of food type: Chewing harder foods (such as carrot) increases muscle activity compared to softer foods (such as banana).

Muscle differences: The masseter muscle shows slightly higher activity in all groups and exhibits greater changes with age compared to the temporalis muscle.

These results indicate that both age and food hardness play important roles in the level of masticatory muscle activity. Comparison with Previous Studies The present study is consistent with the findings of Kohyama et al. (2004), where older adults showed a significant decrease in masseter muscle response to harder foods. Additionally, Hori et al. (2010) attributed the delay in the onset of EMG activity to impaired neuromuscular control and reduced nerve conduction velocity in advanced age.A study by Kiliaridis (2006) also demonstrated that masticatory muscle strength decreases with age, which may lead to reduced tolerance for hard foods.In another study, Türker et al. (2013) reported that changes in the coordination patterns of jaw muscles in elderly individuals could result in decreased efficiency and increased chewing time. Clinical and Practical Implications These findings have important clinical applications. The reduced activity of masticatory muscles in older adults can lead to problems such as:

- Decreased chewing efficiency
- Limited food choices
- Reduced nutrient absorption
- And ultimately, malnutrition

Based on these results, it is recommended that:

- Dietary plans be designed considering the individual's chewing ability (e.g., using soft foods with high nutritional value).
- Physiotherapy exercises for the masticatory muscles be prescribed to maintain muscle strength and response.
- Dental status be assessed and corrected in older adults to improve jaw function.

Conclusion

The present study demonstrated that age is a significant factor influencing the activity patterns of masticatory muscles when chewing foods of varying hardness. With increasing age, not only does the intensity of activity in the masseter and temporalis muscles decrease, but the delay in the onset of muscle activation also increases. These findings suggest a decline in neuromuscular system function associated with aging. Moreover, food hardness significantly increased muscle activity across all age groups; however, the response in older adults was less pronounced. These results may assist healthcare planners, nutritionists, and physiotherapists in designing strategies to improve chewing function in the elderly.

Finally, it is recommended that future studies explore additional factors such as dental status, temporomandibular disorders, and the impact of rehabilitation exercises to gain a more comprehensive understanding of masticatory system function across different age groups.

Author Contributions

Alazahra Saravani, Bayat designed the experiments. Alazahra Saravani nterpreted the results and wrote the manuscript.

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Conflict of Interest

The author declares that there is no conflict of interests regarding the publication of this manuscript.

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Biographies

Alazahra Saravani, a 7th-semester student, and Mahsa Bayat, a 6th-semester student, both in biomedical engineering, have passionately worked on their first article. They are interested in the field of innovation and inventions and continue their path with great enthusiasm.