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Healthy Lifestyle, Autonomic Nervous System Activity, and Sleep Status for Healthy Aging

Miki Sato, Feni Betriana, Ryuichi Tanioka, Kyoko Osaka, Tetsuya Tanioka and Savina Schoenhofer

Abstract

With the super-aging society, it is important to pay attention to the quality of life of older people so that they can face healthy aging. Lifestyle, particularly exercise, autonomic nervous system activities, and sleep status are factors that affect the quality of aging. This chapter explores how those three variables are related and what strategies can be employed to maintain and enhance these variables to prepare. (1) The combination of healthy lifestyles, adequate physical activity, healthy dietary patterns, moderate alcohol consumption, and nonsmoking were related to the risk of cardiovascular diseases. (2) For older people, being physically active is important to the improvement of their physical and mental functions and keeping them independent and mobile. The increasing HRV after exercise might be caused by increasing vagal tone and decreasing sympathetic activity. (3) To reach healthy aging, people should maintain the proper function of autonomic balance activities. This is important because slowing down the decline in sympathetic status might delay many geriatric complaints. (4) To achieve healthy aging, maintaining a healthy sleep is essential. Thus, the key to a lifestyle that facilitates healthy aging is a balance of regular physical exercise and adequate sleep, which mediates and is mediated by autonomic nervous system activity.

Keywords: autonomic nervous activity, lifestyle, exercise, sleep status, healthy aging, and older people

1. Introduction

The world is experiencing an increasing population of older people. Older people are defined by the World Health Organization as people aged 65 years and older [1]. By 2030, it is predicted that 1 in 6 people will be aged 60 years and over, and between 2020 and 2050 people aged 80 years and older will triple to 426 million people worldwide [2].

Unfortunately, increasing age often occurs along with increasing health problems among many older people. A total of 80% older people were reported to have at least one chronic condition, while 68% of older people have two or more chronic

conditions, including hypertension, high cholesterol, diabetes, heart failure, depression, and dementia [3].

Not only chronic diseases, but sleep problems were also frequently reported as a common problem among older people. A study involving 54,722 respondents in 16 countries found that the prevalence of sleep problems among older people in Europe ranged from 16.6% in Italy and Denmark to 31.2% in Poland [4]. Another study by Kim et al. [5] among 3074 older people in South Korea revealed that 29.2% of the participants experience insomnia, while Bhaskar et al. [6] found that 33% of the participants in their study also suffered from chronic insomnia. Insomnia among older people is significantly related to heart disease, anemia, or depression [5], all of which affect healthy aging.

Healthy aging refers to a process of developing and maintaining the functional abilities that allow older people to be and to do things for their well-being [7]. For older people to perform functional abilities, various factors need to be taken into consideration, such as maintaining good sleep and healthy behaviors, including a healthy diet, physical exercise, and refraining from tobacco use [2].

Another factor that contributes to healthy aging is maintaining the balance of the autonomic nervous system (ANS). ANS is a component of the peripheral nervous system that regulates the involuntary physiological process of our body, involving blood pressure, heart rate, respiration, digestion, and sexual arousal [8]. ANS is commonly assessed by heart rate variability (HRV), a measure of the variation in time between each heartbeat [9]. HRV decreases with aging independent of pathological conditions or medication use, potentially suggesting that cardiac autonomic modulation diminishes due to normative aging. Men and women showed similar rates of HRV decline [10].

Understanding how a healthy lifestyle, particularly exercise, ANS, and sleep status are related might assist healthcare professionals to promote healthy aging and prepare older people toward healthy aging.

2. Framework of healthy aging

Healthy aging is characterized by the maintenance of the functional abilities that enable older people to experience well-being [7]. Healthy aging does not mean that older people are free of disease, but the influence of their diseases is minimal that they can still maintain their well-being [7]. The increasing life expectancy resulted in an increasing number of older populations in the world. With super-aging society, it is important to pay attention to the quality of life of older people. Lifestyle particularly exercise, autonomic nervous system activities, and sleep status are factors that affect the quality of aging. This chapter explores how those three variables are related and what strategies can be employed to maintain and enhance these variables to prepare for and achieve healthy aging. (1) The combination of healthy lifestyles, adequate physical activity, healthy dietary patterns, moderate alcohol consumption, and nonsmoking were related to the risk of cardiovascular diseases. (2) Being physically active is important to improve their physical and mental functions and keeping them independent and mobile. (3) To reach healthy aging, people should maintain the proper function of autonomic balance activities. (4) To achieve healthy aging, maintaining a healthy sleep is essential. A healthy sleep involves several dimensions such as adequate sleep duration, good sleep quality, the absence of sleep problems, and appropriate sleep timing. Thus, the key to a lifestyle

Figure 1.
Relationship of maintaining an appropriate lifestyle for healthy aging as physical exercise habit, autonomic nervous activity, and an adequate sleep pattern [11].

that facilitates healthy aging is a balance of regular physical exercise and adequate sleep, which mediates and is mediated by autonomic nervous system activity.

Healthy aging as a relationship between exercise, ANS activity, and adequate sleep is depicted in **Figure 1**. The key to a lifestyle that facilitates healthy aging is a balance of regular physical exercise and adequate sleep, which mediates and is mediated by ANS activity. In this chapter, the authors explore the relationships among healthy lifestyle, physical exercise habits, ANS activity, and adequate sleep to prepare for healthy aging.

3. Health promotion activities for healthy older people

Table 1 presents the activities that can promote healthy aging and the risk factors that might hinder the achievement of healthy aging.

Maintaining a healthy lifestyle is essential to reaching healthy aging. Some elements of a healthy lifestyle include regular physical exercise [12, 13], maintaining an adequate sleep duration [14], and consuming a healthy diet [15].

No.	Health promotion activities	Risk factors
1.	Physical activity habits	Sedentary lifestyle or having little physical activity
2.	Maintaining an adequate sleep	Sleeping fewer than or more than 7–8 hours
3.	Consuming a healthy diet	Excessive alcohol consumption
4.	Nonsmoking	Smoking cigarettes
5.	Maintaining normal body weight	Obesity or malnutrition

Table 1.
Health promotion activities for healthy older people.

Dietary patterns also play an important role in healthy aging. People with higher diet quality were found to have a higher quality of life score [15]. Healthy dietary patterns such as the Nordic diet and Dietary Approaches to Stop Hypertension (DASH) diet were reported to improve self-rated health and quality of life among older people [15]. The Nordic diet is described as a diet with a higher intake of plant foods, egg, fish, and vegetables [16], and the DASH diet is a plant-focused diet, rich in fruits and vegetables, nuts, with low-fat and non-fat dairy, lean meats, fish and poultry, mostly whole grains, and heart-healthy fats [17]. DASH diet has been proven to decrease cholesterol and blood pressure and is associated with a lower risk of heart disease, diabetes, stroke, kidney stone, and several cancers [17].

The combination of these healthy lifestyles, adequate physical activity, healthy dietary pattern, moderate alcohol consumption, and nonsmoking were related to a 57% lower risk of cardiovascular diseases (CVD) and a 67% lower risk of fatal CVD than performing none or one of these healthy lifestyle behaviors [18].

Conversely, some unhealthy behaviors contribute to poor aging and increased mortality risk, including sedentary lifestyle, excessive alcohol consumption, smoking cigarettes, obesity or malnutrition, sleep duration fewer or more than 7–8 hours, having little physical activity, eating between meals, and not eating breakfast.

4. The importance of exercise and problems with sitting behavior

Exercise and physical activity are beneficial to people of all ages. Particularly for older people, being physically active is important to the improvement of their physical and mental functions and keeping them independent and mobile [13]. Habitual physical activity might lower cardiovascular mortality among older people [12]. In a longitudinal Cardiovascular Heart Study, which was conducted among 985 older adults for over 5 years, it was found that older people who increased walking pace or walking distance showed favorable HRV indices more than those who decreased walking pace or distance [12]. The finding that exercise improved HRV was also confirmed by another study [19]. Compared with older people who did not perform the exercise, those who performed exercise training three times per week for 16 weeks showed a significantly greater increase in HRV indices [19]. The increasing HRV after exercise might be caused by increasing vagal tone and decreasing sympathetic activity [20].

In relation with physical activity, two conditions that commonly occur to older people are sarcopenia and dynapenia. Sarcopenia is a syndrome characterized by loss of skeletal muscle mass and function, which is related to physical disability, poor quality of life, and death [21]. Alternatively, dynapenia is the age-related loss of muscle strength that is not caused by neurological or muscular disease [22]. A sedentary lifestyle is a major risk factor for chronic disease, frailty, and sarcopenia as well. Physical activity is defined as any movement produced by contracting skeletal muscles that increase energy expenditure [23].

For a person with sarcopenia, it is important to ensure that the patient receives correct and sufficient nutrition and maintains adequate exercise [21]. Resistance training is an effective way to increase muscle mass and strength, regardless of protein supplementation [24].

Although the importance of physical activities has been specified [25], walking activates muscle activity. **Figure 2** shows that the electric potential of each muscle rises during the stance phase. Also, the measured electromyographic (EMG) activities were significantly correlated with the heel-to-toe pressure of the left foot [26]. When

Figure 2.
The typical surface EMG activity recorded during walking freely at 0.5 km/h in a 21-year-old man, the relationship between the sole pressure and lower limb muscle strength. (A) Electromyogram: Tibialis anterior, gastrocnemius, rectus femoris, hamstrings. (B) Sole, pressure of heel-to-toe, pressure: Heel, Chopard joint, metatarsophalangeal (MP) joint, lateral, thumb, little toe. ST: Standing period, SW: Swinging period. This figure was modified based on Dr. Tetsuya Tanioka, his doctoral dissertation in 2001, Kochi University of Technology.

Figure 3.
A 21-year-old man, the relationship between sole pressure and lower limb muscle strength when walking with a walker (rollator) in a 21-year-old man, the relationship between the sole pressure and lower limb muscle strength. (A) Electromyogram: Tibialis anterior, gastrocnemius, rectus femoris, hamstrings. (B) Sole, pressure of heel-to-toe, pressure: Heel, Chopard joint, metatarsophalangeal (MP) joint, lateral, thumb, little toe. ST: Standing period, SW: Swinging period. This figure was modified based on Dr. Tetsuya Tanioka, his doctoral dissertation in 2001, Kochi University of Technology.

people walk, the heel-to-toe pressure shifted serially from the heel to the metacarpophalangeal (MP) joint to toe area during the standing phase, while the pressure was zero during the swinging phase [26]. Physical activity includes daily activities such as

standing up from a chair and climbing stairs, as well as walking or biking [23]. As you can see from the figure, these activities are intentional movements for health benefits.

However, it has been reported that older adults exhibit greater interstride dynamic instability of muscle activation patterns during gait [27].

The higher activation for the tibialis anterior, while walking slower might be caused by a deviation from the natural walking pattern of the participant [28]. On the contrary, it has been suggested that walking with a four-wheeled walker (rollator) consistently reduced EMG muscle activity in all lower extremity muscle groups and that increased weight-bearing lead to an increased reduction in muscle activity. Rollator-walking reduces lower-limb muscle activity, but trunk-sway remains unchanged as stability is likely gained through forces generated by the upper limbs [29].

As shown in **Figure 3**. High activation of the tibialis anterior is also observed from the electromyogram when walking with a walker.

From the above information, we can see that walking activates the muscles of the lower limbs.

Lower limb muscle strengthening has an impact beyond reducing the risk of falls because the subjects who performed muscle-strengthening activities showed improvement in other areas such as balance, flexibility, and functional capacity. Lower limb muscle strength training is effective for preventing falls. However, this training should be accompanied by the training of other skills, such as balance and gait, and education [30].

5. Characteristics of ANS activity in older people and healthy aging

The balance of the ANS activity is an important element for healthy aging. In older people, the incidence of many diseases occurs, and chronic diseases often appear along with the dysfunction of the ANS [31].

Sympathetic nervous activities are dominant during the daytime due to human activities, working, tension, and stress. On the other side, parasympathetic nervous activities are dominant during nighttime as people are more relaxed, at rest, and asleep. The sympathetic and parasympathetic nerve is switched as needed to maintain balance in the body [32]. If the ANS is in place, this switching will go smoothly. However, if switching is disturbed, it leads to various physical and mental disorders.

Figure 4 shows that sympathetic activation is associated with daytime work, tension, and stress, and parasympathetic activation is associated with rest, relaxation, and sleep. These autonomic nerve activities must be properly switched and balanced. It is important to activate the sympathetic nerve activity with moderate exercise, leading to the recovery mode of the parasympathetic nerve. It is also important to activate the parasympathetic nerve activity by having relaxing meals and bathing.

In older people, ANS, both sympathetic and parasympathetic activities, commonly change. However, it was reported that varied responses existed among changes in sympathetic parameters with age, including increase, decrease, or unchanged [33]. A cross-sectional study which was conducted among 62 healthy persons in India found that sympathetic and parasympathetic responses declined with the increasing age [33]. Another study revealed that sympathetic nervous activity is significantly found to increase during rest as people age [31].

Furthermore, a study by Fuji et al. [34] found that during awake, sympathetic activity, which is indicated by high-frequency (HF) power/low-frequency (LF) power ratio, showed a positive correlation with human activity, which was measured

by actigraph. In contrast, the parasympathetic activity, which was indicated by HF power, increased and showed negative correlations with human activity and sympathetic nervous activity [34]. **Figure 5** shows the typical example of the correlation between sympathetic and parasympathetic activities in a healthy person. Healthy people have high daytime activity values measured by actigraphy and low nighttime

Figure 4.
Sympathetic and parasympathetic activities during daytime and nighttime.

Figure 5.
A typical example of a significant positive correlation between LF/HF and activity count in a healthy person [34].

activity. Sympathetic activity is high during the day in proportion to the activity measured by the actigraph, and parasympathetic activity is high during sleep.

To reach healthy aging, people should keep the balance and maintain the proper function of autonomic balance activities. This is important because slowing down the decline in sympathetic status might delay many geriatric complaints [33].

Two aspects that are frequently mentioned to influence the balance of autonomic activities are physical exercise and sleep. A 1-hour exercise training which is performed three times a week shows improvement in heart rate variability among older people [19]. Meanwhile, poor sleep quality is adversely associated with HRV, heart rate, and blood pressure [35].

6. Sleep status and healthy aging

To achieve healthy aging, maintaining healthy sleep is essential. A healthy sleep involves several dimensions such as adequate sleep duration, good sleep quality, absence of sleep problems, and appropriate sleep timing [36, 37].

Insufficient sleep duration and long sleep duration adversely affect physiological and psychological health. A short sleep duration (less than 6 hours) [14, 38, 39] and long sleep duration that is more than 9 hours [14] are associated with higher prevalence and increased risk of cardiovascular disease, diabetes, stroke, hypertension, and dementia. A study among 10,129 subjects in Iran found that those who slept <6 hours showed a significant risk of CVD, coronary heart diseases (CHD), and hypertension, while those who slept for 8–8.9 hours showed the lowest level of myocardial infarction [38]. Another study among 218,155 participants in Australia found that those who slept <6 hours and > 9 hours had a higher risk of heart diseases, diabetes, stroke, and hypertension compared with those who slept for 7 hours [14].

Not only adequate sleep duration, but the absence of sleep problems is another criterion of healthy sleep. Unfortunately, older people often experience sleep problems due to age-related sleep changes, which result in early waking and fragmented sleep [40]. The common sleep problems, including short sleep duration, poor sleep quality, and later bedtimes are associated with increased food consumption, poor dietary habits, and obesity. Low protein intake was related with difficulty to initiate sleep and poor quality of sleep, while high protein intake and low carbohydrate intake were associated with difficulty to maintain sleep [41].

To improve sleep quality, mood, and quality of life, aerobic physical activity with sleep education about behaviors that help promote sleep can be an effective treatment [42].

Figure 6 shows sleep duration and risk of sleep-related diseases.

Figure 6.
Sleep duration and risks of sleep-related diseases in older adults.

7. Conclusion

This chapter explored the influence of a healthy lifestyle, physical exercise behavior, ANS activity, and adequate sleep on healthy aging. To reach healthy aging, it is recommended that older people adopt a healthy lifestyle, which involves being physically active, consuming a healthy diet, quitting tobacco, and reducing excessive alcohol use. A healthy lifestyle, particularly physical exercise and healthy sleep improve the balance of ANS activity in older people. The ANS involves important aspects for healthy aging. It is also suggested to maintain healthy sleep with adequate duration of 7–8 hours. Short sleep (<6 hours) and oversleep (>9 hours) increase the risk of CVD, coronary heart disease, diabetes, stroke, and hypertension. With these aspects to keep in mind, healthcare professionals are encouraged to promote activities and a healthy lifestyle to help older people reach healthy aging with good quality of life.

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