Open Journal of Psychiatry, 2023, 13, 229-245
https://www.scirp.org/journal/ojpsych
ISSN Online: 2161-7333
ISSN Print: 2161-7325

Characteristics of Sleep and Autonomic Activity in Active Older Adults Based on Metabolic Age: A Comparative Case Study

Miki Sato[1*], Ryuichi Tanioka[2], Feni Betriana[3], Kyoko Osaka[1], Yueren Zhao[4], Tetsuya Tanioka[5], Akira Takahashi[5]

[1]Department of Clinical Nursing, Kochi Medical School, Kochi University, Kochi, Japan
[2]Faculty of Health Sciences, Department of Rehabilitation, Hiroshima Cosmopolitan University, Hiroshima, Japan
[3]Faculty of Nursing, Prince of Songkla University, Hat Yai, Thailand
[4]Department of Psychiatry, Fujita Health University, Aichi, Japan
[5]Institute of Biomedical Sciences, Graduate School, Tokushima University, Tokushima, Japan
Email: *m-sato@kochi-u.ac.jp

How to cite this paper: Sato, M., Tanioka, R., Betriana, F., Osaka, K., Zhao, Y., Tanioka, T. and Takahashi, A. (2023) Characteristics of Sleep and Autonomic Activity in Active Older Adults Based on Metabolic Age: A Comparative Case Study. *Open Journal of Psychiatry*, **13**, 229-245.
https://doi.org/10.4236/ojpsych.2023.134019

Received: June 6, 2023
Accepted: August 27, 2023
Published: August 30, 2023

Abstract

Background: The balance of autonomic nervous system activity and its relationship with body composition, sleep quality, and activities of daily living among older people is still unclear. **Purpose:** This comparative case study examined the characteristics of body composition, sleep quality, and autonomic nerve activity in active older adults with a younger body age-calculated from age trends in body composition and basal metabolic rate. **Methods:** We selected two cases with a metabolic age younger than their actual age. They had good sleep quality, no sarcopenia, strong muscle and grip strength, and balanced autonomic nervous system activity. They were compared with two other age- and gender-matched cases, who had poor sleep quality, unbalanced autonomic nervous system activity, and had a physical age closer to their actual age. **Results:** Older adults with more muscle mass and higher basal metabolism were younger than their actual age, had a better sleep status, and had a good balance of autonomic nervous activity during exercise stimulation. They also had lower percentages of body and visceral fat and higher percentages of body water. **Conclusion:** Two cases had a metabolic age younger than their actual age were found to be much younger than their actual age. However, the older adults with normal muscle mass and basal metabolic rate had poor sleep status and no sympathetic hyperactivity during exercise simulation.

Keywords

Healthy Aging, Autonomic Nervous Activities, Heart Rate Variability, Sleep

Status, Well-Being

1. Introduction

Healthy life expectancy is an indicator that represents a composite of data on mortality and health status. It is defined as the average number of years a person is expected to live with a certain level of health [1]. When compared to 2010, the healthy life expectancy in Japan in 2019 had increased by 2.26 and 1.76 years for men and women, respectively. Over the same period, life expectancy increased by 1.86 and 1.15 years for men and women, respectively. This achieves the target of an increase in healthy life expectancy that exceeded the increase in life expectancy for both sexes [2]. In addition, the duration spent in an unhealthy state was reduced by 0.29 and 0.33 years in men and women, respectively [1]. Therefore, the extension of healthy life expectancy and development of a healthy society are crucial issues [3]. Moreover, age-related changes in personality traits and subjective health affect self-perceived age, which may also affect the extension of healthy life expectancy [4].

In Japan, the average life expectancy has continued to rise, and the country has become one of the leading nations regarding long life expectancy. By 2065, life expectancy in Japan is expected to reach 84.95 and 91.35 years for men and women, respectively. The percentage of people aged 65 years and older has also been increasing; it was 28.4% in 2019 and is expected to reach 33.3% and 38.4% in 2036 and 2065, respectively [5]. In addition to medical factors, health education, community-based public health activities, and legislation for health were responsible for the rapid increase in life expectancy of the Japanese population after World War II [6] [7]. This change has also occurred at the fastest rate globally: the percentage of the older population increased fourfold from 5.7% in 1960 to 23.1% in 2010 [8].

Lifestyle, such as physical exercise, is an important consideration for an aged population [9]. Habitual exercise enhances vagal modulation, resulting in bradycardia. Such vagal modulation could reflect enhancement of parasympathetic control, thus improving both sleep and mood [10]. Sleep affects the resting body by decreasing and increasing sympathetic and parasympathetic nerve activity, respectively [11] [12]. As people age, they experience decreased nighttime sleep quality and lower parasympathetic activity during both sleep and resting [13] [14]. A factor contributing to sleep modulation is a decrease in social activities and physical functions [15]. Lack of exercise has been suggested to increase aging and lead to physical and brain diseases and an overall decrease in quality of life [16] [17].

Many older Japanese people continue to be active and independent, working, enjoying hobbies, and contributing to society [18]. People described as "younger than their age" are thought to have their own lifestyle and manage their lives uniquely [19]. A recent study showed that modifying one's diet and increasing exercise decreased biological age [20], which made people's bodies age slower than their chronological age. Chronological age is defined as the years people have lived, whereas biological age is defined as how old the tissues and cells in the body are, based on physiological evidence [21].

However, the balance of the autonomic nervous system activity, body composition, sleep quality, instrumental activities of daily living, and social activity level in such people is still unclear. Such factors have a significant impact on all the variables of body composition, sleep quality, and physiological age. Hence, clarifying the characteristics of sleep and autonomic nervous system activity in older adults will be useful in creating a foundation for life-long health.

In this paper, the authors aimed to examine the characteristics of body composition, sleep quality, and autonomic nerve activity in active older adults with a younger body age—calculated from age trends in body composition and basal metabolic rate.

2. Methods

2.1. Design and Cases

This study adopted a comparative case study design to examine the differences between the characteristics of body composition, sleep quality, and autonomic activity in active older adults who were younger than their chronological age. This study set the following inclusion criteria: active older people aged 65 years and older who worked in the hospital. Despite the retirement age being 65 years, these participants worked at the hospital in a capacity similar to the working generation (18 - 64 years old). Since some working older adults were not in good health, it was necessary to collect many older adults in this study.

The two cases included in the analysis were those who met the criteria based on data collected from 48 participants. Their activities and daily living abilities were verified by the Japan Science and Technology Agency's ability index (JST-IC) and instrumental activities of daily living (IADL) [22] [23]. This included those who had no identified health problems.

Meanwhile, the exclusion criteria were as follows: those 1) diagnosed with dementia, diabetes, or cancer, 2) severe heart disease or fragile skin conditions, or 3) unable to answer the questions on sleep and lifestyle or did not agree to provide informed consent.

This study selected participants who had good sleep quality according to the Japanese version of the Pittsburgh Sleep Quality Index (PSQI-J), good heart rate variability (HRV) balance which indicated autonomic nervous system activity, good body composition (muscle and body fat mass, grip strength, and sarcopenia assessment), and were younger and fitter than their actual age. For the control cases, age-appropriate older adults were matched by age and gender. These were older men and women with poor sleep quality and imbalanced autonomic nervous system activity whose body age was the same as their actual age.

2.2. Procedures for Data Collection

Figure 1 illustrates the case selection process.

2.3. Indicators

2.3.1. The Japanese Version of the Pittsburgh Sleep Quality Index (PSQI-J)

The participants completed the Japanese version of the PSQI. The PSQI is an internationally standardized scale, and the Japanese version (Cronbach's $\alpha = 0.77$) [24] was found to be reliable and appropriate to assess the lack and subjective quality of sleep [25]. The PSQI's validity has been evaluated in numerous studies [26] [27] [28]. A PSQI-J score of less than 6 was used as the cutoff point to determine good sleep quality [29].

2.3.2. Heart Rate Variability (HRV)

This study measured the participants' HRV using an electrocardiogram to evaluate their sympathetic-parasympathetic balance (MemCalc/Bonaly Light: Suwa Trust, Tokyo, Japan). The coefficients of the variation of RR intervals and high-frequency (HF) power on the electrocardiograph served as indices of parasympathetic nervous activity. In addition, the low-frequency (LF)/HF ratio served as an index of sympathetic nervous activity. Data were analyzed at intervals of 2 seconds. Measurements of LF and HF power components were expressed in normalized units: LFnu and HFnu for sympathetic and parasympathetic nerve activity, respectively. Rest breaks were performed for 1 min after the electrocardiogram electrodes were applied. Next, we asked the participants to

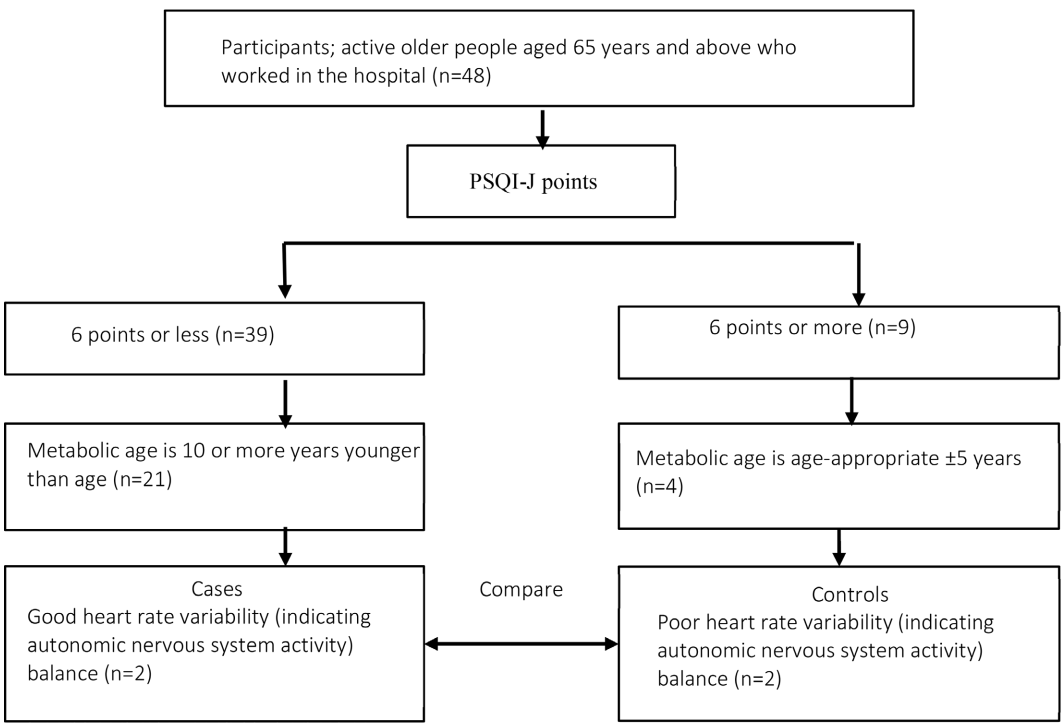

Figure 1. Case selection procedure.

perform flexion and extension of the upper extremities. They raised their arms forward and brought them down after they reached the height of their ears. They performed five repetitions of this movement as one set. To demonstrate the movement, we performed the exercise together in front of the participant. This was followed by a one-minute rest break.

2.3.3. Assessment of Handgrip Strength (HGS)

HGS was measured in all participants. This study used the maximum squeeze results for both the dominant and non-dominant hand. The strength measurement was performed at 90 degrees elbow flexed position using a Jamar dynamometer. HGS of < 26 and 18 kg in men and women, respectively, was considered as low HGS according to the Asian Working Group for Sarcopenia (AWGS 2019) criteria [30].

2.3.4. Bioelectrical Impedance Analysis (BIA)

BIA was measured using a portable BIA device [31] with an eight-electrode configuration, and testing time within 30 - 60 seconds. Tanita monitors use the latest BIA technology, and were first developed in 1992.

Participants avoided strenuous exercise at least 24 hours prior to the assessment and ate their last meal at least 2.5 hours prior. They were asked to empty their bladders and remove all metal objects (e.g. jewelry, keys) before the measurement. Their skeletal muscle mass was automatically calculated from the device. After each assessment, the results were calculated into kilograms for each limb. Subsequently, the muscle masses from four limbs were summed and referred to as appendicular skeletal muscle (ASM). To determine muscle volume, this study calculated the skeleton muscle index (SMI) by BIA using the following formula: ASM (kg)/ht^2. The SMI cut-offs by BIA for the diagnosis of sarcopenia according to the AWGS 2019 criteria [30] were <7.0 and 5.7 kg/m^2 for men and women, respectively.

2.3.5. Body Composition Measurement

This study used the RD-545 InnerScan Pro, which provided an in-depth analysis of body composition measurements that included weight, body fat, muscle mass, muscle quality, body mass, bone mass, visceral fat, basal metabolic rate, metabolic age, total body water, and body mass index (BMI) [32].

2.3.6. Sarcopenia Risk Assessment

This study assessed sarcopenia risk using the Screening for Sarcopenia questionnaire (SARC-F) [33], which allows rapid screening using self-reported data on falls, stair climbing, rising from a chair, walking with assistance, and strength. SARC-F was recommended by the AWGS 2019 as a tool with excellent specificity to screen sarcopenia in community-dwelling older adults [34]. In addition, its reliability and validity have been proven in several studies [35] [36].

2.4. Data Analysis

Data were analyzed using IBM SPSS Statistics for Windows version 29. Welch's analysis of variance (ANOVA) with post-hoc tests (Games-Howell test) were conducted for each case. Significance was set at $p < 0.01$.

2.5. Ethical Considerations

The study was approved by the Ethics Committee of Tokushima University Hospital (#3046), Mifune Hospital Clinical Research Ethics Review Committee, where the study was conducted (#20180502), and the Ethics Committee of Kochi University Hospital (ERB-107865). Informed consent was obtained from the participants before the study began. All participants were informed regarding the purpose of the study and methods used. This study reassured them that their personal information would be protected and kept in a secure location in the researchers' office under lock and key. In addition, the results were reported in aggregate form. The participants were informed that the data generated would be used only for research purposes.

3. Results

3.1. Characteristics of the Cases

This study selected two cases from the 48 participants who had a metabolic age younger than their actual age, good sleep status, and balanced autonomic nervous system activity. These two cases had good sleep quality, low PSQI scores, no sarcopenia, strong muscle and grip strength, balanced autonomic nervous system activity, and were considered to be much younger than their actual age.

The control cases (metabolic age was age-appropriate), had poor sleep quality, unbalanced autonomic nervous system activity, and physical age close to their actual age. Despite the usual retirement age being 65 years, the four cases worked at the hospital in a capacity similar to the working generation (18 - 64 years old). Table 1 shows their basic attributes and measurement values/results.

3.1.1. Cases Whose Metabolic Age Was Younger than Their Actual Age

Case A's physiological (metabolic) age was 15 years younger than her actual age. Her PSQI score indicated a good quality of sleep. Her muscle quality score (Muscle-Q) was comparable to that of older individuals of approximately the same age. Her BMI and body fat showed her to be underweight, although benchmark values for body fat vary according to age and gender.

Case B's physiological (metabolic age) age was also 15 years younger than his actual age. His PSQI score indicated a good quality of sleep. His Muscle-Q score, BMI, and body fat were at the standard level.

3.1.2. Cases Whose Metabolic Age Resembled Their Actual Age

Case C's physiological age was two years older than her actual age. Her Muscle-Q score was at the standard level, and her body fat showed her to be mildly obese. Case D's physiological age was five years younger than his actual age. He had a standard Muscle-Q score, whereas his body fat showed him to be obese.

Table 1. Characteristics of cases' metabolic age and actual age.

Cases	Metabolic age is younger than actual age		Metabolic age is age-appropriate	
	A	B	C	D
Age (years)	69	70	66	75
Gender	Female	Male	Female	Male
Metabolic age	54	55	67	70
PSQI	0	0	8	7
Height (cm)	165.0	166.0	155.0	163.0
Weight (kg)	51.30	60.80	61.70	62.30
BMI	18.8	22.1	25.7	23.5
Muscle-M	37.90	47.80	36.60	43.35
Muscle-Q	32	41	44	37
Body fat (%)	21.6	17.0	37.1	26.6
Visceral-F	3.0	9.5	8.0	12.5
BMR (kcal)	1021	1350	1146	1230
Bone mass (kg)	2.4	2.6	2.2	2.4
Body water (%)	54.5	61.5	48.7	50.3
MM L-ARM (kg)	1.85	2.85	1.70	1.95
MM R-ARM (kg)	1.90	2.85	1.65	2.00
MM L-LEG (kg)	7.25	8.40	6.85	7.45
MM R-LEG (kg)	7.30	8.45	6.80	7.30
MM TRUNK (kg)	19.60	25.25	19.60	24.65
Left grip strength	22.5	22.3	22.5	27.5
Right grip strength	26.1	26.1	20.4	31.9
SMI	6.0	8.0	7.0	7.0
Sarcopenia	-	-	-	-

Note: PSQI: The Japanese version of the Pittsburgh Sleep Quality Index; Metabolic age: calculated by comparing the basal metabolic rate (BMR) with the BMR average of the chronological age group; BMI: body mass index; Muscle-M: whole body muscle mass; Muscle-Q: a score of the muscle mass of the entire body; Body fat (%): proportion of fat to the total body weight; Visceral-F: Visceral fat level; BMR: basal metabolic rate; Bone mass (kg): predicted weight of bone mineral in the body; Body water (%): total amount of fluid in the body expressed as a percentage of total weight; MM L-ARM: left upper limb muscle mass; MM R-ARM: right upper limb muscle mass; MM L-LEG: left lower limb muscle mass; MM R-LEG: right lower limb muscle mass; MM Trunk: trunk muscle mass; SMI: skeletal muscle index; Sarcopenia: decrease in skeletal muscle mass with age.

3.1.3. Cases with Younger Metabolic Age than Their Actual Age

Table 2 shows the measured values of the HR-mean, LFnu, and HFnu before,

Table 2. Characteristics of their autonomic nervous activity (before, during, and after exercise).

		Metabolic age is younger than actual age				Metabolic age is age-appropriate			
Cases		A		B		C		D	
Gender		F		M		F		M	
		N		N		N		N	
HR-mean	(a)	30	105.89 ± 5.18	30	85.05 ± 1.63	30	120.00 ± 2.36	29	93.58 ± 1.61
(Mean ± SD)	(b)	27	105.01 ± 4.81	30	82.93 ± 0.93	27	113.70 ± 4.90	29	86.07 ± 2.33
	(c)	29	92.98 ± 1.89	30	81.12 ± 1.16	30	113.90 ± 3.90	29	85.56 ± 4.22
Post hoc			a > c***		a > b, a > c***		a > b, a > c**		a > b, a > c**
LFnu	(a)	30	55.69 ± 24.31	30	86.59 ± 6.29	30	88.87 ± 6.73	29	83.60 ± 5.05
(Mean ± SD)	(b)	29	75.57 ± 13.22	30	62.36 ± 15.27	29	84.48 ± 10.44	29	63.84 ± 13.06
	(c)	29	71.93 ± 19.31	30	62.21 ± 9.53	30	83.22 ± 6.53	29	78.80 ± 6.50
Post hoc			A < b, a < c**		a > b, a > c**		n.s.		a > b**
HFnu	(a)	30	44.31 ± 24.31	30	13.42 ± 6.29	30	11.13 ± 6.73	29	16.40 ± 5.05
(Mean ± SD)	(b)	29	24.43 ± 13.22	30	37.64 ± 15.27	29	15.53 ± 10.44	29	36.16 ± 13.06
	(c)	29	28.07 ± 19.31	30	37.79 ± 9.53	30	16.78 ± 6.53	29	21.20 ± 6.50
Post hoc			a >b, a > c**		a < b, a < c**		n.s.		a < b**

Note: Welch's ANOVA with post-hoc tests (Games–Howell test). ***$p < 0.001$, **$p < 0.01$, n.s. = not significant. (a) before exercise, (b) during exercise, (c) after exercise.

during, and after exercise, and the results from the mean SD and post-hoc analysis. The results of the post-hoc analysis showed that Case A had a significantly lower HR-mean value after exercise than beforehand ($p < 0.001$). Case B had significantly lower HR-mean values during and after exercise than beforehand ($p < 0.001$).

In addition, Case A had significantly higher LFnu values during and after exercise than before ($p < 0.01$). Meanwhile, Case B had significantly lower LFnu values during and after exercise than beforehand ($p < 0.01$).

Furthermore, Case A had a significantly lower HFnu value during exercise than beforehand ($p < 0.01$), and a significantly lower value after exercise ($p < 0.01$). Meanwhile, Case B showed significantly higher HFnu values during and after exercise than beforehand ($p < 0.01$).

3.1.4. Cases with Age-Appropriate Metabolic Age

The results of the post-hoc analysis of the HR-mean showed that Cases C and D had significantly lower values during and after exercise than beforehand ($p < 0.01$). For LFnu, Case C showed no significant differences, whereas Case D had a significantly lower value during exercise than beforehand ($p < 0.01$). For HFnu, Case C showed no significant differences, whereas Case D had a significantly higher value during exercise than beforehand ($p < 0.01$).

4. Discussion

4.1. Characteristics of Their Metabolic Age

The four cases in our study were as active as the working generation. Their scores for strength, assistance with walking, rising from a chair, stair climbing, falls (SARC-F), and grip strength showed that they did not have sarcopenia. Poor-quality sleep in older adults has been related to functional limitations, such as a reduction in hand grip strength [37] and physical activity [38], and muscle mass and function [39].

Grip strength is thought to be a factor that reveals sleep disorders [40] and problems related to sleep quality and duration [37] [41]. The grip strength of Cases A and B, along with their favorable sleep status, as indicated by their PSQI, appeared to confirm these past studies [37].

Cases A and B had lower percentages of body fat, and their metabolic (physiological age) [32] was 15 years younger than their actual age. Case A had a Muscle-Q score that was standard for women of approximately the same age. Case B's Muscle-Q score was higher than that for men of approximately the same age. Men tend to have significantly greater muscle mass than women in all parts of the body, regardless of age [42]. Case B, a man, was believed to have a larger muscle mass partly due to the influence of total and free testosterone [43].

It has been reported that weight and visceral fat continue to decrease linearly with aerobic exercise [44]; this would explain why older individuals who engaged in extensive physical activity were able to keep themselves in the same physical shape as young people. According to this data, it was suggested that they were able to maintain good physical strength and agility, similar to that of younger adults who had a high metabolic rate, by maintaining a high level of physical activity.

Characteristics of Cases A and B showed lower percentages of body- and visceral fat, and higher body water. For older adults of similar muscle mass, those with higher intracellular water (ICW) had higher functional performance and lower risk of frailty, which suggested that cell hydration had a protective effect independent of muscle mass [45]. However, it is unclear whether the observed positive effect of high ICW content was due to greater muscle mass or better muscle quality and cell hydration [46].

Body water percentage tends to be higher in men than in women [47] and decreases with age [46]. It also tends to be lower and higher in those with a high and low body fat percentage, respectively [46]. The body water percentage of people whose body fat percentage was within the proper range was approximately 55% - 65% for men and 45% - 60% for women [31]. The body water percentage of Cases A and B were within the appropriate range.

Cases C and D also had high grip strengths, and neither had sarcopenia. Owing to their activity levels that were comparable to the working generation, their Muscle-Q scores were assessed as being standard values for people of their generation. However, their sleep quality was poor. Researchers have reported that in ordinary aging, sleep debt had a negative impact on carbohydrate metabolism and endocrine function, which suggested that a lack of sleep aggravated age-related chronic diseases [48]. Even older people who have few comorbidities and lead independent lives experience decreasing sleep quality (PSQI) as age increases.

Cases C and D had high body fat, and their physiological age was close to their actual age. Cases C (female) and D (male) had poor-quality sleep. Women have a high risk of metabolic syndrome, regardless of their sleep duration, whereas in men, the shorter the sleep duration, the higher their risk [49]. Sleep duration of five hours or less also affects the distribution of centrosome fat and causes an increase in body fat percentage [50]. The process by which lack of sleep leads to obesity may involve changes in the neuroendocrine system and metabolism, as well as behaviors/activities engaged in while awake [51]. Although weight and body fat may be constant, the distribution of fat changes with age. In addition, there is a higher risk of it shifting to the abdominal area [32]. Therefore, attention should be paid to buildup of visceral fat often attributable to age-related decreases in sleep quality, aside from the body fat percentage.

4.2. Characteristics of Their Autonomic Nervous Activity

Regarding the HR-mean, Cases A, C, and D had high pulse rates, even when resting prior to exercising. Given that older adults generally engage in less physical activity and have a slower metabolism than adults, their pulse rate is reportedly 10 to 20 pulses per minute lower than that in adults. Hence, the heart rates of these three cases may have risen owing to psychological tension, such as dealing with unfamiliar researchers whom they had not met before, being placed in the unfamiliar setting of a conference room, and undergoing examinations [52].

The cases' pulses were significantly lower after exercise than beforehand. However, the pulses were not significantly higher during exercise than beforehand. Case A, a woman, had a significantly higher HR before exercise than after. Her sympathetic nerve activity was significantly higher during and after exercise than beforehand—it did not decline even after exercise. Case B, a man, showed lower sympathetic nerve activity during and after exercise than beforehand. Case C, a woman, showed no changes in her sympathetic nerve activity before, during, or after exercise.

During exercise, cardiovascular parameters change to supply oxygen to the working muscles and preserve the perfusion of vital organs. At the onset of exercise, heart rate (and cardiac output) elevation is mostly mediated by central command signals via vagal withdrawal. As work intensity increases and the heart rate approaches 100 beats/min, sympathetic activity begins to rise, further increasing the heart rate and plasma norepinephrine concentration and vasoconstricting vessels in visceral organs. With exercise cessation, the loss of central command, baroreflex activation, and other mechanisms contribute to a rise in parasympathetic activity, causing a decrease in heart rate despite maintained sympathetic activation [53].

Post-exercise exponential decline of the heart rate is an intrinsic property of intact circulation and is independent of autonomic control. The heart rate rapidly decreases during the first 1 - 2 min after exercise cessation, and then gradually thereafter. During recovery from moderate and heavy exercise, the heart rate remains elevated above the pre-exercise level for a relatively long period (up to 60 min). The increase in parasympathetic activity causing heart rate deceleration after exercise is independent of basal parasympathetic tone to a large extent [54].

The action of the sympathetic nerves does not change significantly even with age. Meanwhile, the action of the parasympathetic nervous system reportedly declines with age, making people likely to fall into a state of autonomic imbalance, with only the sympathetic nerves functioning strongly [55]. Moreover, during mild exercise, if the load is too light, sympathetic nervous activity cannot be sufficiently controlled [56].

In our study, however, Case A experienced no reduction in sympathetic nervous activity during or after exercise. Furthermore, Case C saw no changes attributable to exercise, with the sympathetic nerve activity predominating; that is, no switchover to the parasympathetic nervous system had taken place. Research has noted that the higher a person's aerobic exercise ability, the swifter their post-exercise HRV recovery [57]. Our participants were extremely active in their everyday lives and exerted themselves to a level comparable to that of the working generation. Thus, they were physically young and it influenced the switchover to autonomic nervous activity.

Regular physical activity has positive effects on cardiovagal nerve activity and decreases the influence of aging on the autonomic nerve control of the heart rate [58]. Our participants' average pulse was significantly lower after exercise than beforehand. However, since sympathetic nervous activity in Case D was greater beforehand than during exercise, pre-exercise psychological stress appeared to have decreased with exercise.

A balanced diet and high sleep quality are known to be important in regulating the autonomic nervous system. Habitual physical exercise reportedly reduces the risk of lifestyle diseases and deterioration in life functions. Furthermore, it is useful for maintaining and enhancing endurance and muscular strength [59], and can help reduce locomotive syndrome and mild cognitive disorder [60]. Meanwhile, since light-intensity physical activity is effective in improving the subjective sleep quality of older adults, while moderate to vigorous physical activity has the opposite effect [57], continued light exercise may be effective in improving sleep quality. Raising the intensity of existing physical activity at work, in daily life, or during regular leisure activities appears to be useful in preventing premature death [61]. To increase healthy life expectancy, people should be encouraged to increase their level of physical activity, such as exercise and work, as well as to regulate their meals and sleep and maintain a low level of autonomic nervous system activity.

4.3. Implication, Strengths, and Limitations

This comparative case study compared two pairs of older people with opposite muscle mass, basal metabolic rate, and sleep status. The results demonstrated that older adults with more muscle mass and higher basal metabolism were younger than their actual age, and had better sleep status and a good balance of autonomic nervous activity. These findings can be used to notify healthcare professionals of the importance of promoting physical activity among older adults.

However, this comparative case was a small-scale study conducted to inform, predict, and direct an intended future full-scale study. It revealed that older adults with more muscle mass and higher basal metabolic rate were younger than their actual age and had better sleep status. Large-scale studies should be conducted to clarify the living conditions including dietary habits and lifestyles of older adults with the aforementioned health conditions.

5. Conclusion

In this comparative case study, two older adult cases had a metabolic age younger than their actual age, a good sleep status, and balanced autonomic nervous system activity. Hence, older adults with more muscle mass and higher basal metabolism were younger than their actual age and benefitted from having a better sleep status and a good balance of autonomic nervous activity due to exercise stimulation. They also had lower percentages of body- and visceral fat, and higher body water. Meanwhile, two older adult cases with standard muscle mass and basal metabolic rate had a poor sleep status. In addition, their sympathetic nervous system was not elevated during exercise. Hence, by maintaining physical activity, reducing body fat, and increasing muscle mass, people can maintain good sleep and keep their body and mind young as they age, which may lead to an increase in healthy life expectancy.

Acknowledgements

The authors would like to express their gratitude and deep appreciation to the individuals who participated in this comparative case study.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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