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Research article

Proposal of Need Care Indicators for the Male Elderly People -An Approach Based on Phase Angle

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Abstract

Phase angle (PhA) has become a sudden focus of attention in recent years. However, much remains unknown about its relationship with health indicators. If it is an indicator derived through bioelectrical impedance analysis (BIA), its meaning as a simple health indicator can probably be established. In this study, we analyzed the changes in phase angle with age in general elderly men, and constructed a span evaluation chart based on those changes with age. The phase angle of men who require care was applied to the constructed span evaluation chart, and standards for care need level were sought. The results showed a trend for the phase angle in people who require care to be distributed at below 5.5° for the whole body and 4.0° for the legs. Thus, the phase angle of people who require care was revealed to be distributed in the range of −1.0 ± 1.0 SD that of general elderly men. Using the phase angle aging span evaluation chart, a standard for care need level was presented and its validity as a health care indicator in the elderly is thought to have been shown.

Keywords: Phase angle, male elderly people, need care indicators, wavelet interpolation model

Introduction

There is an indicator of nutritional status that has become a sudden focus of attention in recent years, an indicator that reflects the level of cellular activity. That indicator is called phase angle (Ph A), and it can be easily measured with bioelectrical impedance analysis (BIA). This indicator is the impedance (Z) of the vector value expressed with the resistance (R) originating from the intracellular and extracellular fluid, the reactance (Xc) originating from the cell membrane, and the square root of the square of R and the square of Xc. Likening the cell membrane to a condenser, reactance (Xc) produces a deviation in the lag phase in the current over time with voltage. Hence, phase angle is the arc tangent of Xc divided by R. Phase angle illuminates the state of the cell membrane and intracellular fluid, showing low values with increased dead cells or decreased cell permeability, and high values with increases in cells with high activity levels. It is reported to be particularly useful in predicting the survival rate in cancer patients [1]. Tsutsumi et al. [2] stated that there is significant correlation between the seriousness of the disease and phase angle in patients with advanced disease, but that uniform conclusions have not been reached on whether it is effective as a prognostic indicator. However, from the potential for high utilization as a nutritional indicator, it can be inferred that phase angle shows the level of physical activity. Moreover, since phase angle illuminates the relationship between the intracellular and extracellular fluid, derived from resistance (R) and reactance (Xc), it is taken to be a quality parameter of muscle [3]. According to Yamada et al. [4], phase angle increased with increased muscle mass and increased intracellular fluid in muscle. Uemura et al. [5] indicated the possibility that it could be a comprehensive indicator in evaluating frailty and sarcopenia in older adults, as well as changes in disease prognostic indicators and physical health.

On the other hand, care prevention is taken to mean "preventing (delaying) as much as possible the onset of a state of needing care, preventing as much as possible the worsening of the state of needing care if it does occur, and aiming to mitigate that state"[1]. According to a report by Tsutsumi et al. [2], factors in coming to need care include physical factors, psychological factors, and social factors. Care prevention efforts include improvement of the exercise function and the physical function of nutrition status in elderly people, and the provision of services such as those adjusting the dietary environment. Improvement of the living functions (activity level) of elderly people and participation in events (role level) is also facilitated, and extension of healthy life expectancy is sought [1]. Specifically, the decline in physical ability with walking impairments is closely related to the need for care [2], and a care prevention approach for physical factors is important. However, when judged from the degree of decline in physical function, the state of care need is not clear. Hence, health indicators have not been established for people moving into care facilities, and in communities with a concentration of elderly people in particular supply of care facilities has not kept up. In other words, care facilities are not being sufficiently used.

The establishment of a new health care indicator in elderly people is therefore thought to be necessary. In fact, Fujii et al. [6] used phase angle in high school sports team members and a general control group, and showed that the height of the phase angle in the sports team members reflected their level of physical activity. This suggested that phase angle is useful in evaluating the level of physical activity. Therefore, phase angle is promising as an indicator of care need health care.

In fact, Takeyama et al. [7] analyzed the changes with age in phase angle in old age in Japan using elderly women. They then constructed an aging span evaluation chart with consideration of age-related changes, and proposed care need standards using phase angle. However, Hayakawa et al. [8] and Barbosa-Silva et al. [9] reported racial and sex differences in phase angle. Thus, much remains unknown about the changes in phase angle with age in the different sexes.

In this study, we calculated phase angle based on BIA and investigated the changes with age in elderly men from age 60 to 90. Next, using the wavelet interpolation model, we constructed an aging span standardization chart for phase angle and attempted to standardize the changes with age in phase angle in elderly men. We then applied the phase angle values for elderly men who require care to the constructed aging span standardization chart. Here, we propose a health indicator for care prevention care based on phase angle.

Methods

Subjects and methods

The subjects of this study were 61 healthy, general elderly men who participated in a care prevention class put on by a local municipality and 5 care-requiring elderly men who used a certain day service facility. A breakdown of the subjects is shown in Table 1. The content of the survey and measurements were explained to the subjects in advance, and their informed consent was obtained.

Physical composition measurements

Height was measured using a digital height rod (Tanita). Weight and resistance (R), reactance (Xc), and impedance (Z) were measured using a Tanita MC-780 body composition analyzer that employs bioelectrical impedance analysis (BIA). BIA is a method in which impedance (Z) is measured when a weak electrical current is passed through the body and the physical composition of the body is estimated. By likening the body's cell membranes to a condenser and body fluid components to a conductor, the cell membranes and body fluid components (intracellular fluid, extracellular fluid) are thought to be a combined electrical circuit. Impedance (Z) is a vector value expressed by the square root of the square of resistance (R), which is the resistance of body water with intra- and extracellular fluids as the conductor, and the square of reactance (Xc), the electrical capacitance resistance of the cell membrane. Therefore, impedance (Z) is calculated using the formula below (1).

$$Z^2=R^2+Xc^2 \quad (1)$$

Phase angle is the arc tangent value when reactance (Xc) is divided by resistance (R). Therefore, phase angle is calculated using the formula below (2).

$$\text{Phase angle}=-\text{Arctangent} \times Xc/R \times (180°)/\pi \quad (2)$$

Analysis methods

[Wavelet Interpolation Model]

The wavelet interpolation method (WIM) interpolates data point and data point with a wavelet function to approximately describe true growth curves from given data, and draws a growth distance curve. In this method, the drawn distance curve is then differentiated, the obtained growth velocity curve is derived,

Table 1. Age, physique, and phase angle of general elderly males and elderly male in needing care

Elderly Male	General elderly male (n=61)	Elderly male in needing care (n=5)
Age	72.44±6.47	74.80±4.21
Height (cm)	163.57±6.54	161.20±3.70
Weight (kg)	62.27±10.46	65.54±16.46
Body fat percentage (%)	19.92±5.94	23.74±15.55
BMI	23.20±3.13	25.40±7.44
Phase angle (whole-body)	5.67±0.72	5.22±0.57
Phase angle (lower extremity)	4.94±0.89	3.99±0.96

Analysis procedures

1) Phase angle is calculated based on BIA, and wavelet interpolation model is applied for phase angle (whole body, legs) in general elderly men. We investigated the changes with age in elderly men from age 60 to 90.

2) By applying the wavelet interpolation model to the age axis that shows each age classification of phase angle, an aging span standardization chart with 10-year increments is constructed.

3) Elderly care-requiring men are applied to the constructed phase angle aging span standardization chart, and the phase angle distribution status is analyzed.

and the growth distance value at the pubertal peak or time of menarche is investigated. The effectiveness of the wavelet interpolation model is that it sensitively reads local phenomena and has a very high approximation accuracy. The theoretical background and effectiveness of the wavelet interpolation method is described in previous studies by Fujii [10-12]. When the wavelet interpolation model is applied to longitudinal data for height, a growth distance curve is drawn. A growth velocity curve is then drawn by differentiating that growth distance curve. In this study, the wavelet interpolation model was applied not to height but to the changes with age in phase angle. A distance curve for changes with age in phase angle was then drawn, and the trend in changes with age was analyzed from the phase angle growth velocity curve derived by differentiating that distance curve.

Result

For the changes in phase angle with age, means and standard deviations were calculated in 10-year intervals. The center point of the 10-year intervals was then set on the age axis, and the wavelet interpolation model was applied to the means and standard deviations (±1.0 SD) for phase angle at the age points of 65, 75, and 85 years old. As shown in Figures 1, phase angle showed a gradually declining trend from around age 70. It was also shown that the width of the standard deviation band narrowed after age 80 beyond the average life expectancy.

Figures 2 and 3 show the application of the constructed phase angle aging evaluation chart to elderly care-requiring men. The result shows a clearly lower distribution of phase angle. Thus, low phase angles were seen in nearly all people requiring care. Looking at the trends in detail, it is seen that the distribution is in the range of −1.0 ± 1.0 SD that of general elderly men. In particular, it is clear that care-requiring elderly have a distribution in the vicinity of −1.0 SD on the aging evaluation chart. Table 2 shows the individual evaluation values calculated in the care-requiring elderly from the means and standard deviations for each age. As a result, it was confirmed that the evaluation value for phase angles of the whole body and legs were included within −1.0 ± 1.0 SD.

Discussion

The mean age of general elderly men in the control group in this study was 72.44±6.47 years old, and phase angle was 5.67±0.72°. Looking at the changes in phase angle with age in each age group, it was seen that whole body and leg phase angle decreased from around 65 to 70 years old. After a slight leveling off, a rapidly decreasing trend was shown after 70. Uemura [5], with respect to phase angle in elderly men (65–90 years old), reported that the phase angle was 5.5±0.5° at a mean age of 73.6±5.3 years old (n=98), which was about the same as the subjects in this study. In addition, in elderly men of 60 and older, a decreasing trend in phase angle was reported with age, confirming the validity of the control group in this study.

In this study, the wavelet interpolation model was applied to changes in phase angle with age in the whole body and the legs, and the trends in the changes with age in both of these phase angles were analyzed. In the whole-body phase angle, the velocity curve shows a local peak at around age 70, after which it shows a rapidly decreasing trend. Consequently, the trend in phase angle shows a large change at around age 70 in both the whole body and the legs, suggesting rapid changes in physical health condition after the age of 70. In women, a marked decreasing trend in phase angle was shown at around the age of 80, revealing that the decrease is delayed by about 10 years compared with men. The interval of this delayed decrease, considering the shorter av-

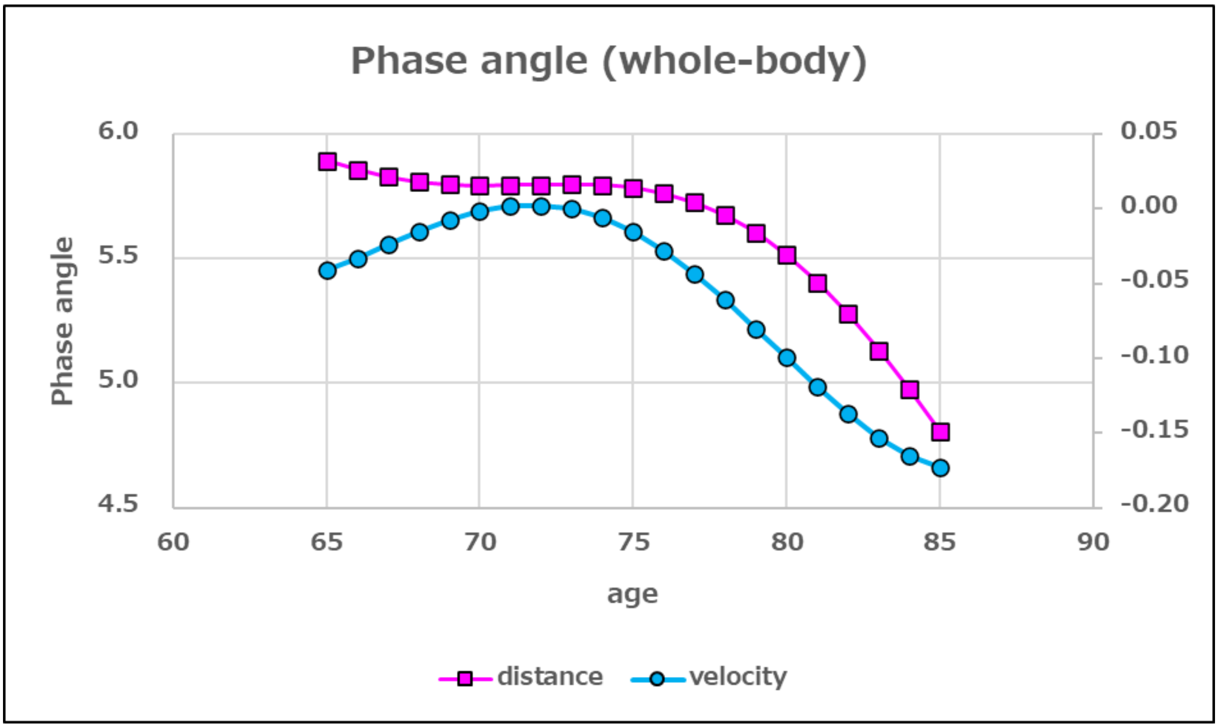

Figure 1. Age-related changes in phase angle (whole-body) in general elderly male (Application of wavelet interpolation model)

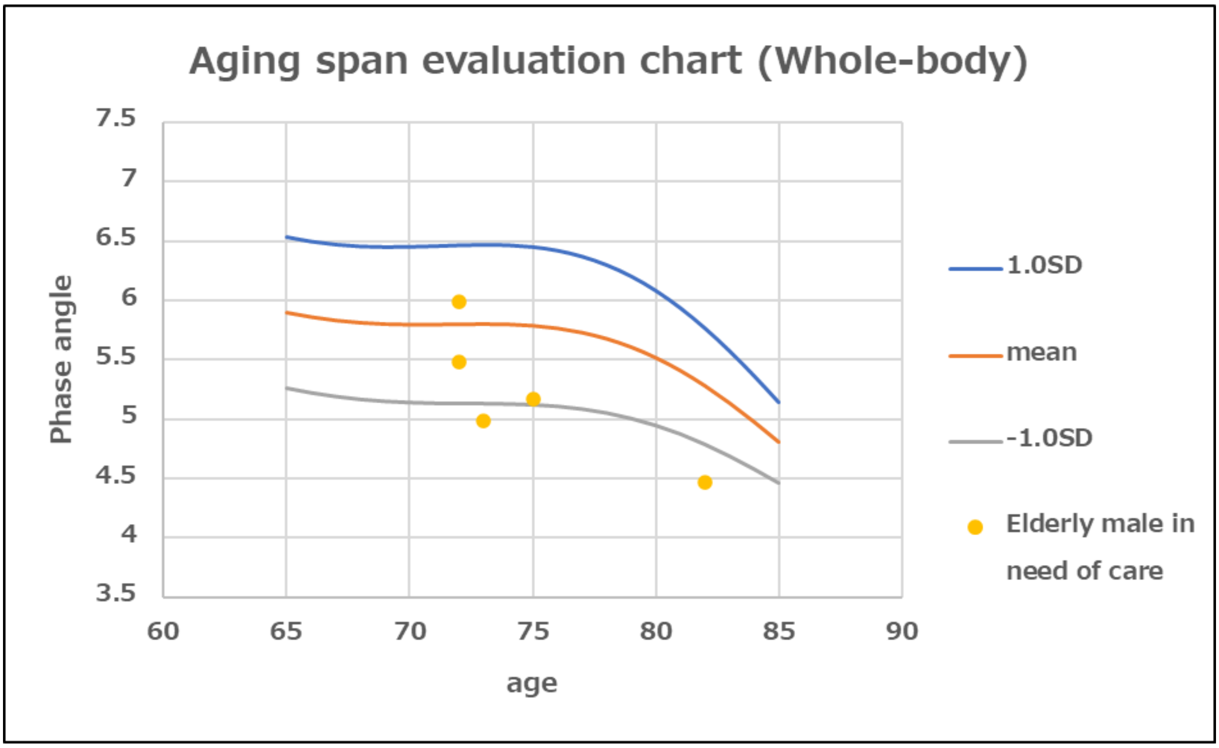

Figure 2. Application to the aging span evaluation chart (whole-body) for elderly male in needing care

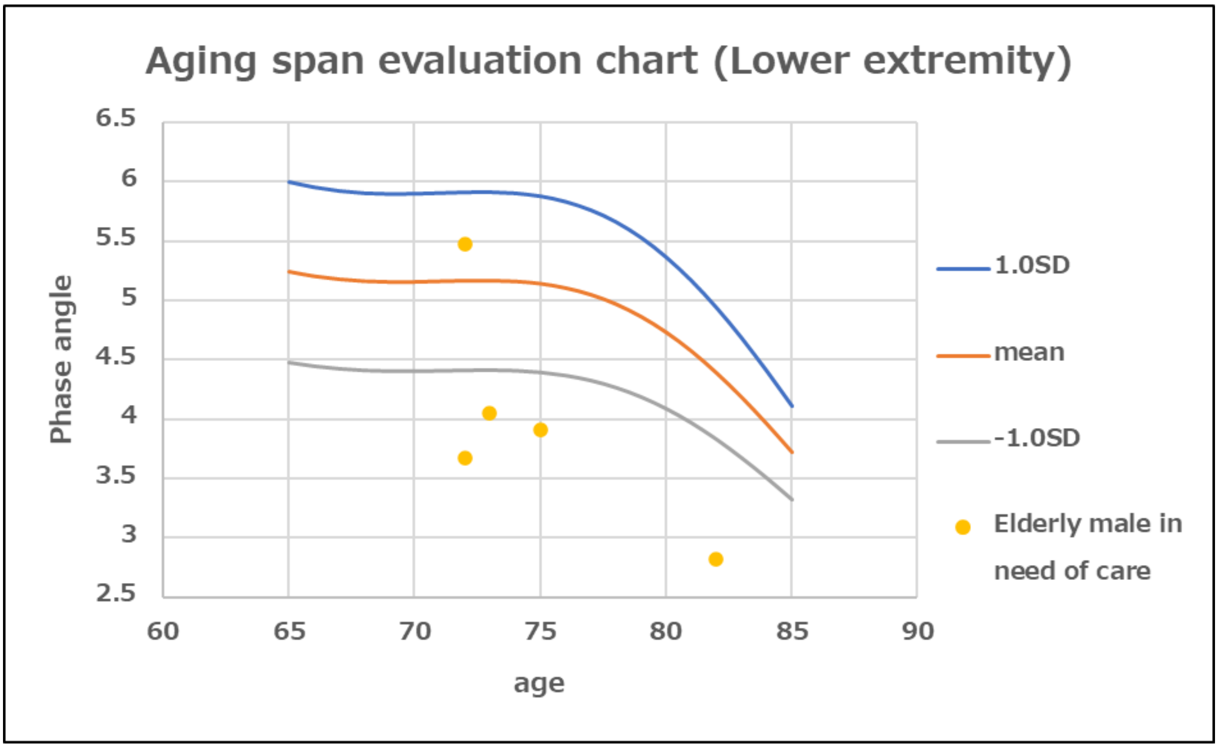

Figure 3. Application to the aging span evaluation chart (lower extremity) for elderly male in needing care

erage life expectancy in males, would truly seem to suggest the physical activity levels of elderly people proposed by Fujii et al. [6]. Hence, it may be that after the age of 70 in men and the age of 80 in women are critical points for the rapid decline in physical activity level.

From the above, the evaluation of phase angle with age in elderly men from age 65 to 80 was clarified by constructing a phase angle aging span evaluation chart for elderly men. For a detailed evaluation, when judged from the distribution trends in phase angle for the legs and the whole body, the whole body was 5.22±0.57° and the legs were 3.99±0.96°, and the distribution in care-requiring elderly was found to be below 5.5° in the whole body and below 4.0° in the legs. Thus, it was shown to be distributed in a range of −1.0±1.0 SD that of general elderly men. Therefore, the relationship between changes in phase angle with age and the care need level was shown by constructing a phase angle aging span evaluation chart, and it was indicated that if phase angle declines below 5.5° in the whole body and below 4.0° in the legs, the care need level health risk becomes higher.

Therefore, in attempting to extend healthy life expectancy as health care, it would seem to be important to maintain a continuously high evaluation band on a standardized chart. In the future, if phase angle is demonstrated to be an indicator that is a health risk cut-off value in a larger number of care-requiring subjects, it may be possible to construct a more definitive indicator of health care in care need. These findings may be considered to show that phase angle can be understood as a new physical activity level in elderly people that is effective as an indicator of health care in care need.

Conclusion

In this study, we built an aging span evaluation chart and evaluated phase angle with age in these elderly men aged 65 to 85 by applying the wavelet interpolation model. In addition, by applying the values for elderly care-requiring men to the standardization chart, the amount of difference with the standard level was demonstrated and the trends in phase angle for care need level were shown. As a result, it was revealed that the trend in phase angle in elderly care-requiring men was distributed at below 5.5° (whole body) and 4.0° (legs), in the range of −1.0±1.0 SD that in general elderly men. This suggests that we can attempt to extend healthy life expectancy by maintaining a high evaluation band with the standardization chart.

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