The Effects of 12 Weeks of a Combined Exercise Program on Physical Function and Hormonal Status in Elderly Korean Women

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Abstract: Aging causes a decline in physical function and hormonal balance. Exercise can improve these parameters. However, the beneficial effects of a combined exercise program (Korean dance and yoga) on physical function and hormonal status in elderly women remain unknown. This study aims to investigate the effects of a 12-week combined exercise program on balance, flexibility, muscle strength, and hormonal status in elderly Korean women. Twenty-five healthy elderly women were recruited and randomly divided into the control (CON) and exercise (EXE) groups. The EXE group underwent the combined exercise program (60 min/day and 3 times/week) for 12 weeks. The two groups did not differ in body weight, lean body mass, fat mass, body fat percentage, or body mass index at baseline or in the changes following the experimental conditions. A significant time × group interaction was detected for anterior and posterior dynamic balance, static balance, and growth hormone (GH). After the combined exercise program, anterior dynamic balance, posterior dynamic balance, static balance, flexibility, muscle strength, GH, dehydroepiandrosterone-sulfate, and estrogen significantly increased in the EXE group compared to the CON group. In conclusion, the combined exercise program contributed to improvements in overall health, including physical function and hormonal status, in elderly Korean women.

Keywords: elderly women; combined exercise; growth hormone; dehydroepiandrosterone sulfate; estrogen

1. Introduction

The elderly population aged >65 years accounted for 14.3% of the total Korean population in 2018 [1], and it is estimated to increase further from 24.3% in 2030 to 40.1% in 2060 [2]. Aging contributes to the multifactorial process that causes decline in physical activity levels, resulting in metabolic dysfunction and unbalanced hormonal status [3,4]. The increasing health costs due to aging urgently need to be addressed [5]. Thus, the maintenance of healthy aging by performing physical activity, promoting self-sufficiency, and providing leisure time becomes an important public health issue for improving an individual’s strength.

Variations in physical function and balanced hormonal status are among the important determinants of health and functional capacity in elderly women and men [6,7]. In particular, postmenopausal elderly women show decreased balance, resulting in falling accidents which cause muscle injuries, fractures, and neuromuscular dysfunctions [8,9]. Flexibility, defined as the range of motion of a given joint, decreases by up to 50% during aging [10]. Elderly women experience a
decline in flexibility and muscle strength, which compromises the physical activities of daily living [11].
Therefore, improving these parameters is crucial in healthy elderly women.

Aging coupled with a sedentary lifestyle is accompanied by progressive decline in muscle strength, growth hormone (GH), dehydroepiandrosterone-sulfate (DHEA-S), and estrogen, which results in the rapid loss of skeletal muscle mass, greater fall injuries, impaired walking ability, and poor quality of life of elderly women [3,12,13]. GH is a peptide hormone that stimulates growth and cell reproduction and is stimulated by sex hormones such as testosterone, DHEA-S, and estrogen [14]; these regulate human development [15]. Decreases in GH contribute to the reduction of lean body mass and muscle strength as well as to increased body fat with aging [16]. Estrogen, the primary female sex hormone, is considered to play a significant role in women’s mental health as well as in the maintenance of bone mineral density and immune function [17]. DHEA-S is an endogenously produced sex steroid associated with anti-aging effects [18]. Decline in estrogen levels with aging is associated with reduced muscle strength in elderly women [19]. In elderly men, decline in DHEA-S levels is found to begin at the age of 65 years [20] and causes muscle weakness [21]. In elderly women, DHEA-S levels are negatively correlated with aging [22,23]. Therefore, the clinical meaning of DHEA-S levels in elderly women remains unclear.

Exercise programs are widely recommended to ameliorate aging-associated dysfunction through improvement in physical function and hormonal balance because of their low cost and non-pharmacological strategy [24]. Exercise is a useful tool for improving physical function, inhibiting hormonal deficiency, and maintaining the optimal quality of life in elderly women [25–28]. Thus, an exercise program is one of the most effective activities for the aging population. In Korea, local community exercise programs include a Korean dance that is one of the most popular physical activities for elderly women [29]. The Korean dance involves moving the limbs to traditional music [30]. Therefore, interventions based on traditional Korean dance represent an attractive therapeutic strategy to improve body composition in elderly women [31]. For example, the Korean dance can improve balance and attenuate falls and medical costs, suggesting that this program promotes healthy life and prevents fall accidents in the elderly [32]. Kim et al. [33] investigated the effect of the Korean dance on health-related fitness and blood lipids in elderly Korean women who participated in a Korean dance program for 12 weeks. They reported a significant improvement in grip strength and high-density lipoprotein cholesterol levels. These results suggest that the Korean dance is associated with a dynamic exercise program. In other studies, 12 weeks of a yoga exercise program, which is a representative static exercise, showed a possible beneficial effect in maintaining GH and DHEA-S, thus promoting healthy aging [34]. Alves et al. [35] reported that 12 weeks of a yoga exercise program improved flexibility, balance, coordination, and strength levels [36]. These factors contribute to the prevention of falls and improvement of higher physical activities of daily living [37]. Taken together, the Korean dance and yoga programs have a beneficial effect on physical function and hormonal status for elderly adults. However, the effects of the combined Korean dance and yoga exercise program for healthy aging remain unknown.

This study aimed to evaluate the effects of a 12-week combined exercise program on balance, flexibility, muscle strength, GH, DHEA-S, and estrogen in healthy elderly women. We hypothesized that the combined exercise program might improve balance, flexibility, muscle strength, GH, DHEA-S, and estrogen in this population.

2. Materials and Methods

2.1. Ethics Approval and Consent to Participate

The study was approved by the Chang Won University’s Ethics Committee (1040271–201802–004). All procedures were performed in accordance with the Declaration of Helsinki for research on human subjects. All participants provided informed consent prior to participation.
2.2. Participants and Study Design

A total of 34 Korean women, who were post-menopausal for at least five years, were recruited from a local community fitness center and voluntarily participated in the study. Four and five participants were excluded due to health issues and non-completion of the study intervention, respectively. Subsequently, the participants were randomly assigned to the following two groups at baseline: control group (CON, n = 11, mean age 69.36 ± 2.94 years) and exercise group (EXE, n = 14, mean age 71.57 ± 3.22 years). The flow chart of the selection process is shown in Figure 1. The baseline characteristics of the subjects are presented in Table 1.

The inclusion criteria were as follows: age ≥65 years, never having attended an exercise program, and had not participated in yoga or Korean dance lessons for the six months prior to the study. The exclusion criteria included a history of medical problems such as cardiovascular disease, musculoskeletal limitations, obesity, diabetes, and brain-related disease. In addition, the participants could not be taking any medication for hormonal and metabolic dysfunction. Balance, flexibility, muscle strength, and blood samples were evaluated at baseline (week 0) and post-exercise intervention (week 12). All data were collected at the same time of day (9:00 a.m.) after a day of performing the final combined exercise program and fasting for 12 h. The EXE (n = 14) group performed an exercise program (at 10:00 a.m., 60 min/day and 3 times/week) that included warming up (5 min), the main exercise (50 min), and

Figure 1. Flow diagram of the study.
cool down (5 min) for 12 weeks. The combined exercise program included yoga and Korean dance for 12 weeks. The CON group (n = 11) did not perform any exercise program, but were supervised in the fitness center at the same frequency and time, and performed sedentary physical activities, such as listening to music, reading a book, and watching TV. The CON and EXE groups were strictly advised to maintain their regular physical activity and dietary habits during the intervention. All measurements and exercises were performed using standardized protocols with two expert investigators.

Table 1. Description of the combined exercise program performed by the exercise group.

| Exercise | Duration | Frequency | Week | Intensity |
|----------|----------|-----------|------|-----------|
| Warm up | Stretching | 5 min | 3 times/week | 1–6 | RPE 12 |
| Main exercise | Static balance exercise | Valdidim, Parlsawe, Zainngareem, Saetaryeong | 30 min | 6–12 | RPE 13 |
| Dynamic balance exercise | A sitting position, Sitting Forward Bend Pose, Butterfly Pose, Bat Pose, God of the Half Fishes Pose, Cow Facing Pose | 20 min | |
| Cool-down | Stretching, respiration arrangement, and meditation (Baddha Konasana) | 5 min | |

RPE: rating of perceived exertion.

2.3. Perceived Exertion

The rating of perceived exertion (RPE) was assessed using the 20-point Borg scale of perceived exertion (6 = extremely easy to 20 = extremely hard) [38]. A participant’s RPE was assessed during each exercise intervention by supervisors.

2.4. Exercise Program

Each participant performed a supervised combined exercise program (yoga and Korean dance) for 60 min per day, 3 times per week with an RPE of 12–13. The program is shown in Table 2. The combined exercise program was supervised by a professional expert, and none of the participants performed any other exercise program during the study period.

Table 2. Demographic characteristics at baseline and 12 weeks in the control and exercise groups.

| Variable | Control Group (n = 11) | Exercise Group (n = 14) | Effects (p-value) |
|----------|------------------------|-------------------------|-------------------|
| Age (years) | 69.36 ± 2.94 | 71.57 ± 3.22 | N.A. |
| Height (cm) | 154.63 ± 5.04 | 153.57 ± 3.22 | N.A. |
| Weight (kg) | 62.83 ± 7.58 | 63.00 ± 7.11 | N.A. |
| LBM (kg) | 39.40 ± 4.39 | 39.02 ± 4.50 | N.A. |
| FM (kg) | 23.41 ± 3.98 | 21.72 ± 5.52 | 0.377 |
| BF (%) | 37.19 ± 2.93 | 36.58 ± 4.73 | 0.542 |
| BMI (kg.m−2) | 26.36 ± 2.38 | 24.77 ± 2.84 | 0.868 |

1 LBM: lean body mass; FM: fat mass; BF: body fat percentage; BMI: body mass index; N.A.: non-applicable.

2.5. Assessment of Body Composition, Balance, Flexibility, and Muscle Strength

Body composition. The participants arrived at the venue and were given a 30 min break. Then, their body composition was evaluated using bioelectrical impedance analysis (BIA) (InBody 520, Biospace Co., Seoul, Korea). We obtained height (cm), body weight (kg), body fat mass (FM) (kg), lean body mass (LBM) (kg), and body mass index (BMI—calculated as body mass divided by the height squared (kg/m²)) pre- and post-intervention.
**Static balance and dynamic balance ability.** Balance was measured using the Center of Pressure measuring method of the Humac Norm Balance System (Computer Sports Medicine Inc., Boston, MA, USA). The protocols were performed according to a previous study [39].

**Flexibility.** Participants performed the chair sit-and-reach test according to the senior fitness test protocol as described previously [40]. The participants had three trial attempts and the highest score was recorded.

**Muscle strength.** Participants performed the chair stand test according to the senior fitness test protocol as described previously [40].

### 2.6. Blood Collection and Measurements

Blood samples were obtained from the vein at baseline (week 0) and post intervention (week 12) after 12 h of fasting. The blood was collected in serum-separating tubes, centrifuged for 10 min at $1977 \times g$ to obtain the serum without other components of blood, and immediately frozen at $-80 \degree C$ until analyzed. GH level was measured using a chemiluminescence immunoassay method (Siemens, Los Angeles, CA, USA). DHEA-S level was measured by performing the electrochemiluminescence immunoassay method (Roche Diagnostics GmbH, Mannheim, Germany), and estrogen level was measured using the radioimmunoassay method (Perkin Elmer, Boston, MA, USA).

### 2.7. Statistics

All data are presented as means ± standard deviation. To determine data normality, we used the Shapiro–Wilk test. A two-way analysis of variance (ANOVA) with repeated measures [group (CON and EXE) × time (baseline and post-12 weeks)] was used to determine the difference in the changes in the dependent variables between baseline and post-combined exercise programs within and between groups with a post-hoc Bonferroni test. When a significant interaction was noted, paired t-tests were used for post-hoc comparisons. The level of significance was set to $p < 0.05$. Student’s t-test (unpaired) (post–baseline) was used to determine the changes in the variables and the difference between groups for change ($\Delta$).

### 3. Results

Table 2 shows the demographic characteristics of the participants at baseline and 12 weeks after the two experimental conditions. At baseline, there were no differences in age, height, weight, LBM, FM, BF, and BMI between the groups. No differences were found in body weight, LBM, FM, BF percentage, and BMI between baseline and after the two experimental conditions in both groups (Table 2).

A significant time × group interaction was detected for anterior ($p = 0.016$) and posterior dynamic balance ($p = 0.032$), static balance ($p = 0.003$), and GH ($p = 0.037$) (Table 3). After the combined exercise program, in the EXE group, anterior dynamic balance ($p = 0.009$), posterior dynamic balance ($p = 0.008$), static balance ($p = 0.010$), flexibility ($p = 0.040$), muscle strength ($p = 0.030$), GH ($p = 0.040$), DHEA-S ($p = 0.003$), and estrogen ($p = 0.046$) significantly increased compared to those of the CON group (Figure 2A–H).
The main finding of this study is that there was a significant improvement in anterior dynamic balance, posterior dynamic balance, static balance, flexibility, muscle strength as well as in GH, DHEA-S, and estrogen levels following training in elderly Korean women.

4. Discussion

To the best of our knowledge, this is the first study investigating the effect of a combined exercise program on anterior dynamic balance, posterior dynamic balance, static balance, flexibility, muscle strength, GH, DHEA-S, and estrogen in elderly Korean women. The main finding of this study is that there was a significant improvement in anterior dynamic balance, posterior dynamic balance, static balance, flexibility, muscle strength as well as in GH, DHEA-S, and estrogen levels following training in elderly Korean women.

Aging is associated with a decline in physical function (i.e., balance, flexibility, and muscle strength) and hormonal status (i.e., GH, DHEA-S, and estrogen) [34,41–44]. Previous studies have also reported that an exercise program improves physical function and prevents hormonal deficiency in elderly women [45,46]. However, the effects of a combined exercise program that includes Korean dance, which is a dynamic exercise, and yoga, which is a static exercise, on these parameters have not been investigated.

Table 3. Participants’ anterior dynamic balance, posterior dynamic balance, static balance, flexibility, muscle strength, growth hormone (GH), dehydroepiandrosterone-sulfate (DHEA-S), and estrogen at baseline and 12 weeks post-intervention in the control or exercise group.

| Variable                  | Control Group (n = 11) | Exercise Group (n = 14) | Effects (p-Value) |
|---------------------------|------------------------|-------------------------|-------------------|
|                           | Baseline               | 12 Weeks               | Time              | Group | Time × Group |
| Anterior dynamic balance  | 32.18 ± 3.81           | 30.09 ± 6.90           | 0.270             | 0.012 | 0.016       |
| balance (sec)             |                        |                        |                   |       |             |
| Posterior dynamic balance | 22.27 ± 4.62           | 21.64 ± 5.10           | 0.15              | 0.072 | 0.032       |
| balance (sec)             |                        |                        |                   |       |             |
| Static balance (sec)      | 87.18 ± 3.60           | 86.71 ± 3.60           | 0.008             | 0.014 | 0.003       |
| Flexibility (cm)          | 11.36 ± 9.40           | 10.57 ± 8.59           | 0.51              | 0.452 | 0.284       |
| Muscle strength (ng/mL)   | 1.35 ± 0.41            | 1.14 ± 0.46            | 0.109             | 0.278 | 0.037       |
| GH (ng/mL)                | 19.38 ± 6.90           | 18.11 ± 7.49           | 0.001             | 0.001 | 0.066       |
| DHEA-S (µg/mL)            | 46.89 ± 20.01          | 75.90 ± 40.84          | 0.568             | 0.010 | 0.332       |
| Estrogen (pg/mL)          | 26.36 ± 2.38           | 24.77 ± 2.84           | 0.868             | 0.062 | 0.820       |

Figure 2. Changes in anterior dynamic balance, posterior dynamic balance, static balance, flexibility, muscle strength, growth hormone (GH), dehydroepiandrosterone-sulfate (DHEA-S), and estrogen from baseline to 12-weeks post-intervention in the control (CON) or exercise (EXE) group. * p < 0.05 compared to CON, ** p < 0.01 compared to CON. Values are presented as mean ± SD. (A) anterior dynamic balance (p = 0.009), (B) posterior dynamic balance (p = 0.008), (C) static balance (p = 0.010), (D) flexibility (p = 0.040), (E) muscle strength (p = 0.030), (F) GH (p = 0.040), (G) DHEA-S (p = 0.003), and (H) estrogen (p = 0.046).
yet been reported. In this study, we tested whether a moderately intense combined Korean dance and yoga exercise program may contribute to increased balance, flexibility, muscle strength, GH, DHEA-S, and estrogen levels. We found a significantly greater increase in balance, flexibility, and muscle strength following the combined exercise program compared to the control group. The findings of our study suggest that increased balance, flexibility, and muscle strength reduce fall occurrence and improve optimal quality of life in elderly women. These observations are consistent with those of a previous study that reported an increase in balance and flexibility following a yoga exercise program [47,48]. It is also possible that Korean dance is associated with an increase in muscular strength [33]. Taken together, these results may lead to a decline of fall incidents among the elderly [49–51].

Aging is related to a decline in the endocrine system. In recent years, accumulating evidence suggests the therapeutic role of GH, DHEA-S, and estrogen in elderly women [52–54]. A deficiency of GH during aging increases adiposity and decreases LBM [55]. Another study reported that administration of GH improved the body composition, such as FM and LBM, suggesting GH administration as an anti-aging treatment [56,57]. However, a previous study suggested that GH treatment may cause various side effects, such as joint pain and edema [58,59]. To avoid these side effects, we studied the beneficial effects of the combined exercise program—which is suggested to ameliorate the side effects—on body composition. In the present study, we found that the combined exercise program induced an improvement of GH, and increased GH was not associated with improvement in body composition. These findings are congruent with those of previous investigations demonstrating that an increase in GH through combined exercises is not associated with muscle mass and strength [58].

Fukai et al. [60] demonstrated that a higher DHEA-S level contributes to the improvement in physical activity levels and activities of daily living in elderly women. Other studies reported that low DHEA-S levels are associated with depressive symptoms and cognitive impairment in aging people [61,62]. It is necessary to study a therapeutic strategy to normalize and improve DHEA-S levels. In this study, we tested whether the combined exercise program played a role in regulating DHEA-S levels. We found that this exercise program increased DHEA-S levels, suggesting that this therapeutic exercise program may address depressive symptoms and cognitive impairment in elderly women. Reduction in estrogen levels due to aging contributes to the loss of LBM, resulting in unhealthy lifestyle [63]. In terms of the effects of estrogen levels after the combined exercise program, we found that the EXE group did not show improvement in LBM compared to the CON group, but we found a significant increase in estrogen levels in the EXE group, which was in line with the results of a previous study by Chun et al. [64], who found that a combined exercise program was effective in improving estrogen levels. Keriie et al. [65] suggested that 12 weeks of endurance exercise training increased estrogen levels in postmenopausal women. Taken together, these results support the assumption that a combined exercise program could be a new therapeutic tool for improving the hormonal status of elderly women.

The current study has several limitations. First, it included a small sample size (n = 25). Second, the participants were limited to elderly women (age = 65 years). Third, it was not possible to evaluate the isolated effect of the exercise protocol; hence, we could not provide the beneficial effect of each exercise program (Korean dance alone or yoga alone). In the future, it will be necessary to conduct a study involving a larger sample size with participants of different ages. Moreover, the effects of each exercise intervention should be separately investigated.

5. Conclusions

The 12-week combined exercise program significantly increased the anterior dynamic balance, posterior dynamic balance, static balance, flexibility, muscle strength, GH, DHEA-S, and estrogen levels of elderly Korean women. These findings provide evidence that a combined exercise program may serve as a new exercise strategy for healthy aging among Korean women.
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References

1. Statistical Research Institute. Social Trend of Korea 2018; Korea National Statistical Office, Statistical Research Institute: Daejeon, Korea, 2018.

2. Statistical Research Institute. Social Trend of Korea 2013; Korea National Statistical Office, Statistical Research Institute: Daejeon, Korea, 2013.

3. Bartke, A. Growth Hormone and Aging: Updated Review. World J. Mens Health 2019, 37, 19–30. [CrossRef] [PubMed]

4. Nilsson, A.; Santoro, A.; Franceschi, C.; Kadi, F. Detrimental links between physical inactivity, metabolic risk and N-glycomic biomarkers of aging. Exp. Gerontol. 2019, 124, 110626. [CrossRef] [PubMed]

5. Martini, E.M.; Garrett, N.; Lindquist, T.; Isham, G.J. The boomers are coming: A total cost of care model of the impact of population aging on health care costs in the United States by Major Practice Category. Health Serv. Res. 2007, 42, 201–218. [CrossRef] [PubMed]

6. Velez, M.P.; Rosendaal, N.; Alvarado, B.; da Camara, S.; Belanger, E.; Pirkle, C.M. Data on the association between age at natural menopause and physical function in older women from the International Mobility in Aging Study (IMIAS). Data Brief. 2019, 23, 103811. [CrossRef]

7. Mayhew, A.J.; Griffith, L.E.; Gilsing, A.; Beauchamp, M.K.; Kuspinar, A.; Raina, P. The association between self-reported and performance-based physical function with activities of daily living disability in the Canadian Longitudinal Study on Aging. J. Gerontol. A Biol. Sci. Med. Sci. 2019. Epub ahead of print. [CrossRef]

8. Dipietro, L.; Campbell, W.W.; Buchner, D.M.; Erickson, K.I.; Powell, K.E.; Bloodgood, B.; Hughes, T.; Day, K.R.; Piercy, K.L.; Vaux-Bjerke, A.; et al. Physical Activity, Injurious Falls, and Physical Function in Aging: An Umbrella Review. Med. Sci. Sports Exerc. 2019, 51, 1303–1313. [CrossRef] [PubMed]

9. Konak, H.E.; Kibar, S.; Ergin, E.S. The effect of single-task and dual-task balance exercise programs on balance performance in adults with osteoporosis: A randomized controlled preliminary trial. Osteoporos Int. 2016, 27, 3271–3278. [CrossRef]

10. Stathokostas, L.; Little, R.M.; Vandervoort, A.A.; Paterson, D.H. Flexibility training and functional ability in older adults: A systematic review. J. Aging Res. 2012, 2012, 306818. [CrossRef]

11. Stathokostas, L.; McDonald, M.W.; Little, R.M.; Paterson, D.H. Flexibility of older adults aged 55-86 years and the influence of physical activity. J. Aging Res. 2013, 2013, 743843. [CrossRef]

12. Trivedi, D.P.; Khaw, K.T. Dehydroepiandrosterone sulfate and mortality in elderly men and women. J. Clin. Endocrinol. Metab. 2001, 86, 4171–4177. [CrossRef]

13. Vincent, A.; Riggs, B.L.; Atkinson, E.J.; Oberg, A.L.; Khosla, S. Effect of estrogen replacement therapy on parathyroid hormone secretion in elderly postmenopausal women. Menopause 2003, 10, 165–171. [CrossRef] [PubMed]

14. Meinhardt, U.J.; Ho, K.K. Modulation of growth hormone action by sex steroids. Clin. Endocrinol. (Oxf) 2006, 65, 413–422. [CrossRef] [PubMed]

15. Greenwood, F.C.; Landon, J. Growth hormone secretion in response to stress in man. Nature 1966, 210, 540–541. [CrossRef]

16. Roy, T.A.; Blackman, M.R.; Harman, S.M.; Tobin, J.D.; Schrager, M.; Metter, E.J. Interrelationships of serum testosterone and free testosterone index with FFM and strength in aging men. Am. J. Physiol. Endocrinol. Metab. 2002, 283, E284–E294. [CrossRef]

17. Darabi, M.; Ani, M.; Panjehpour, M.; Rabbani, M.; Movahedian, A.; Zarean, E. Effect of estrogen receptor beta A1730G polymorphism on ABCA1 gene expression response to postmenopausal hormone replacement therapy. Genet. Test. Mol. Biomarkers 2011, 15, 11–15. [CrossRef] [PubMed]
18. Kawata, H.; Yanase, T.; Goto, K.; Okabe, T.; Ashida, K. Mechanism of action of anti-aging DHEA-S and the replacement of DHEA-S. Mech. Ageing Dev. 2002, 123, 1101–1106. [CrossRef]

19. Vandevyver, C.; Vanhoof, J.; Declerck, K.; Stinissen, P.; Vandervoort, C.; Michiels, L.; Cassiman, J.J.; Boonen, S.; Raus, J.; Geusens, P. Lack of association between estrogen receptor genotypes and bone mineral density, fracture history, or muscle strength in elderly women. J. Bone Miner. Res. 1999, 14, 1576–1582. [CrossRef]

20. Orentreich, N.; Brind, J.L.; Rizer, R.L.; Vogelman, J.H. Age changes and sex differences in serum dehydroepiandrosterone sulfate concentrations throughout adulthood. J. Clin. Endocrinol. Metab. 1984, 59, 551–555. [CrossRef]

21. Valenti, G.; Denti, L.; Maggio, M.; Ceda, G.; Volpato, S.; Bandinelli, S.; Ceresini, G.; Cappola, A.; Guralnik, J.M.; Ferrucci, L. Effect of DHEAS on skeletal muscle over the life span: The InCHIANTI study. J. Gerontol. A Biol. Sci. Med. Sci. 2004, 59, 466–472. [CrossRef]

22. Kahonen, M.H.; Tilvis, R.S.; Jolkkonen, J.; Pitkala, K.; Harkonen, M. Predictors and clinical significance of declining plasma dehydroepiandrosterone sulfate in old age. Aging (Milano) 2000, 12, 308–314.

23. Mazat, L.; Lafont, S.; Berr, C.; Debuire, B.; Tessier, J.F.; Dartigues, J.F.; Baulieu, E.E. Prospective measurements of dehydroepiandrosterone sulfate in a cohort of elderly subjects: Relationship to gender, subjective health, smoking habits, and 10-year mortality. Proc. Natl. Acad. Sci. USA 2001, 98, 8145–8150. [CrossRef] [PubMed]

24. Monico-Neto, M.; Antunes, H.K.; Dattilo, M.; Medeiros, A.; Souza, H.S.; de Melo, C.M.; Tufik, S.; de Mello, M.T. Resistance exercise: A non-pharmacological strategy to minimize or reverse sleep deprivation-induced muscle atrophy. Med. Hypotheses 2013, 80, 701–705. [CrossRef] [PubMed]

25. Ferreira, C.B.; Teixeira, P.D.S.; Alves Dos Santos, G.; Dantas Maya, A.T.; Americano do Brasil, P.; Souza, V.C.; Cordova, C.; Ferreira, A.P.; Lima, R.M.; Nobrega, O.T. Effects of a 12-Week Exercise Training Program on Physical Function in Institutionalized Frail Elderly. J. Aging Res. 2018, 2018, 7218102. [CrossRef] [PubMed]

26. Geirsdottir, O.G.; Arnarson, A.; Ramel, A.; Briem, K.; Jonsson, P.V.; Thorsdottir, I. Muscular strength and physical function in elderly adults 6-18 months after a 12-week resistance exercise program. Scand. J. Public Health 2015, 43, 76–82. [CrossRef]

27. Borst, S.E.; Millard, W.J.; Lowenthal, D.T. Growth hormone, exercise, and aging: The future of therapy for the frail elderly. J. Am. Geriatr. Soc. 1994, 42, 528–535. [CrossRef] [PubMed]

28. Swift, D.L.; Earnest, C.P.; Blair, S.N.; Church, T.S. The effect of different doses of aerobic exercise training on endothelial function in postmenopausal women with elevated blood pressure: Results from the DREW study. Br. J. Sports Med. 2012, 46, 753–758. [CrossRef]

29. Lim, S.T.; Min, S.K.; Park, H.; Park, J.H.; Park, J.K. Effects of a healthy lifestyle exercise program on artherosclerosis adhesion molecules in elderly women. J. Phys. Ther. Sci. 2015, 27, 1529–1532. [CrossRef]

30. Jang, H.R.; Lee, J.H.; Lee, S.K. The comparison of body composition, functional performance ability, talar tilt angle and foot injuries in accordance with the functional ankle instability in high school traditional Korean dance majors. Korea Dance Educ. Soc. J. 2014, 25, 149–162.

31. Park, J.H.; Park, H.; Lim, S.T.; Park, J.K. Effects of a 12-week healthy-life exercise program on oxidized low-density lipoprotein cholesterol and carotid intima-media thickness in obese elderly women. J. Phys. Ther. Sci. 2015, 27, 1435–1439. [CrossRef]

32. Jeon, M.Y.; Bark, E.S.; Lee, E.G.; Im, J.S.; Jeong, B.S.; Choe, E.S. The effects of a Korean traditional dance movement program in elderly women. Taehan Kanho Hakhoe Chi 2005, 35, 1268–1276. [CrossRef]

33. Kim, S.M.; Park, H.J.; Min, B.J.; So, W.Y. Effects of a Korean Traditional Dance Program on Health-related Fitness and Blood Lipid Profiles in Korean Elderly Females. Iran. J. Public Health 2018, 47, 127–129. [PubMed]

34. Chatterjee, S.; Mondal, S. Effect of regular yogic training on growth hormone and dehydroepiandrosterone sulfate as an endocrine marker of aging. Evid. Based Complement. Altern. Med. 2014, 2014, 240581. [CrossRef] [PubMed]

35. Chaya, M.S.; Kurpad, A.V.; Nagendra, H.R.; Nagarathna, R. The effect of long term combined yoga practice on the basal metabolic rate of healthy adults. BMC Complement. Altern. Med. 2006, 6, 28. [CrossRef] [PubMed]

36. Raub, J.A. Psychophysiologic effects of Hatha Yoga on musculoskeletal and cardiopulmonary function: A literature review. J. Altern. Complement. Med. 2002, 8, 797–812. [CrossRef]

37. Seco, J.; Abecia, L.C.; Echevarria, E.; Barbero, I.; Torres-Unda, J.; Rodriguez, V.; Calvo, J.I. A long-term physical activity training program increases strength and flexibility, and improves balance in older adults. Rehabil. Nurs. 2013, 38, 37–47. [CrossRef]
38. Scherr, J.; Wolfarth, B.; Christie, J.W.; Pressler, A.; Wagenpfeil, S.; Halle, M. Associations between Borg’s rating of perceived exertion and physiological measures of exercise intensity. *Eur. J. Appl. Physiol.* 2013, 113, 147–155. [CrossRef]

39. Park, J.M.; Hyun, G.S.; Jee, Y.S. Effects of pilates core stability exercises on the balance abilities of archers. *J. Exerc. Rehabil.* 2016, 12, 553–558. [CrossRef]

40. Adamo, D.E.; Talley, S.A.; Goldberg, A. Age and task differences in functional fitness in older women: Comparisons with Senior Fitness Test normative and criterion-referenced data. *J. Aging Phys. Act.* 2015, 23, 47–54. [CrossRef]

41. Dugan, S.A.; Gabriel, K.P.; Lange-Maia, B.S.; Karvonen-Gutierrez, C. Physical Activity and Physical Function: Moving and Aging. *Obstet. Gynecol. Clin. N. Am.* 2018, 45, 723–736. [CrossRef]

42. Patel, K.V.; Phelan, E.A.; Leveille, S.G.; Lamb, S.E.; Missikpode, C.; Wallace, R.B.; Guralnik, J.M.; Turk, D.C. High prevalence of falls, fear of falling, and impaired balance in older adults with pain in the United States: Findings from the 2011 National Health and Aging Trends Study. *J. Am. Geriatr. Soc.* 2014, 62, 1844–1852. [CrossRef]

43. Calcada, D.; Vianello, D.; Giampieri, E.; Sala, C.; Castellani, G.; de Graaf, A.; Kremer, B.; van Ommen, B.; Feskens, E.; Santoro, A.; et al. The role of low-grade inflammation and metabolic flexibility in aging and nutritional modulation thereof: A systems biology approach. *Mech. Ageing Dev.* 2014, 136–137, 138–147. [CrossRef] [PubMed]

44. Somani, Y.B.; Pawelczyk, J.A.; De Souza, M.J.; Kris-Etherton, P.M.; Proctor, D.N. Aging women and their endothelium: Probing the relative role of estrogen on vasodilator function. *Am. J. Physiol. Heart. Circ. Physiol.* 2019, 317, H395–H404. [CrossRef] [PubMed]

45. Nigdelis, M.P.; Martinez-Dominguez, S.J.; Goulis, D.G.; Perez-Lopez, F.R. Effect of programmed exercise on perceived stress in middle-aged and old women: A meta-analysis of randomized trials. *Maturitas* 2018, 114, 1–8. [CrossRef]

46. Furtado, H.L.; Sousa, N.; Simao, R.; Pereira, F.D.; Vilaca-Alves, J. Physical exercise and functional fitness in independently living vs. institutionalized elderly women: A comparison of 60- to 79-year-old city dwellers. *Clin. Intern. Aging* 2015, 10, 795–801. [PubMed]

47. Santaella, D.F.; Devesa, C.R.; Rojo, M.R.; Amato, M.B.; Drager, L.F.; Casali, K.R.; Montano, N.; Lorenzi-Filho, G. Yoga respiratory training improves respiratory function and cardiac sympathovagal balance in elderly subjects: A randomised controlled trial. *BMJ Open* 2011, 1, e000085. [CrossRef]

48. Youkhana, S.; Dean, C.M.; Wolff, M.; Sherrington, C.; Tiedemann, A. Yoga-based exercise improves balance and mobility in people aged 60 and over: A systematic review and meta-analysis. *Age Ageing* 2016, 45, 21–29. [CrossRef]

49. Melzer, J.; Benjuya, N.; Kaplanski, J. Postural stability in the elderly: A comparison between fallers and non-fallers. *Age Ageing* 2004, 33, 602–607. [CrossRef]

50. Muir, S.W.; Berg, K.; Chesworth, B.M.; Klar, N.; Speechley, M. Modifiable Risk Factors Identify People Who Transition from Non-fallers to Fallers in Community-Dwelling Older Adults: A Prospective Study. *Physiother. Can.* 2010, 62, 358–367. [CrossRef]

51. Thomas, E.; Battaglia, G.; Patti, A.; Brusa, J.; Leonardi, V.; Palma, A.; Bellafiore, M. Physical activity programs for balance and fall prevention in elderly: A systematic review. *Medicine (Baltimore)* 2019, 98, e16218. [CrossRef]

52. Smeets, E.; Schutzler, S.E.; Wei, J.Y.; Azhar, G.; Wolfe, R.R. Do anabolic nutritional supplements stimulate human growth hormone secretion in elderly women with heart failure? *Physiol. Rep.* 2017, 5, e13366. [CrossRef]

53. Morrison, M.F.; Freeman, E.W.; Lin, H.; Sammel, M.D. Higher DHEA-S (dehydroepiandrosterone sulfate) levels are associated with depressive symptoms during the menopausal transition: Results from the PENN Ovarian Aging Study. *Arch. Womens Ment. Health* 2011, 14, 375–382. [CrossRef] [PubMed]

54. Matthews, C.E.; Sampson, J.N.; Brenner, D.R.; Moore, S.C.; Courneya, K.S.; Ziegler, R.G.; Friedenreich, C.M. Effects of Exercise and Cardiorespiratory Fitness on Estrogen Metabolism in Postmenopausal Women. *Cancer Epidemiol. Biomark. Prev.* 2018, 27, 1480–1482. [CrossRef] [PubMed]

55. Li Voon Chong, J.S.; Benbow, S.; Foy, P.; Wallymahmed, M.E.; Wile, D.; MacFarlane, I.A. Elderly people with hypothalamic-pituitary disease and growth hormone deficiency: Lipid profiles, body composition and quality of life compared with control subjects. *Clin. Endocrinol. (Oxf)* 2000, 53, 551–559. [CrossRef] [PubMed]
56. Rudman, D.; Feller, A.G.; Nagraj, H.S.; Gergans, G.A.; Lalitha, P.Y.; Goldberg, A.F.; Schlenker, R.A.; Cohn, L.; Rudman, I.W.; Mattson, D.E. Effects of human growth hormone in men over 60 years old. *N. Engl. J. Med.* 1990, 323, 1–6. [CrossRef]

57. Holloway, L.; Butterfield, G.; Hintz, R.L.; Gesundheit, N.; Marcus, R. Effects of recombinant human growth hormone on metabolic indices, body composition, and bone turnover in healthy elderly women. *J. Clin. Endocrinol. Metab.* 1994, 79, 470–479.

58. Blackman, M.R.; Sorkin, J.D.; Munzer, T.; Bellantoni, M.F.; Busby-Whitehead, J.; Stevens, T.E.; Jayme, J.; O’Connor, K.G.; Christmas, C.; Tobin, J.D.; et al. Growth hormone and sex steroid administration in healthy aged women and men: A randomized controlled trial. *JAMA* 2002, 288, 2282–2292. [CrossRef]

59. Liu, H.; Bravata, D.M.; Olkin, I.; Nayak, S.; Roberts, B.; Garber, A.M.; Hoffman, A.R. Systematic review: The safety and efficacy of growth hormone in the healthy elderly. *Ann. Intern. Med.* 2007, 146, 104–115. [CrossRef]

60. Fukai, S.; Akishita, M.; Yamada, S.; Hama, T.; Ogawa, S.; Iijima, K.; Eto, M.; Kozaki, K.; Toba, K.; Ouchi, Y. Association of plasma sex hormone levels with functional decline in elderly men and women. *Geriatr. Gerontol. Int.* 2009, 9, 282–289. [CrossRef]

61. Goldman, N.; Glei, D.A. Sex differences in the relationship between DHEAS and health. *Exp. Gerontol.* 2007, 42, 979–987. [CrossRef]

62. Morsink, L.F.; Vogelzangs, N.; Nicklas, B.J.; Beekman, A.T.; Satterfield, S.; Rubin, S.M.; Yaffe, K.; Simonsick, E.; Newman, A.B.; Kritchevsky, S.B.; et al. Associations between sex steroid hormone levels and depressive symptoms in elderly men and women: Results from the Health ABC study. *Psychoneuroendocrinology* 2007, 32, 874–883. [CrossRef]

63. Munsell, M.F.; Sprague, B.L.; Berry, D.A.; Chisholm, G.; Trentham-Dietz, A. Body mass index and breast cancer risk according to postmenopausal estrogen-progestin use and hormone receptor status. *Epidemiol. Rev.* 2014, 36, 114–136. [CrossRef] [PubMed]

64. Xiao, C.M.; Kang, Y.; Zhuang, Y.C. Effects of Elastic Resistance Band Exercise on Postural Balance, Estrogen, Bone Metabolism Index, and Muscle Strength of Perimenopausal Period Women. *J. Am. Geriatr. Soc.* 2016, 64, 1368–1370. [CrossRef] [PubMed]

65. Moreau, K.L.; Stauffer, B.L.; Kohrt, W.M.; Seals, D.R. Essential role of estrogen for improvements in vascular endothelial function with endurance exercise in postmenopausal women. *J. Clin. Endocrinol. Metab.* 2013, 98, 4507–4515. [CrossRef] [PubMed]