science, engineering and health studies

Research Article

Science, Engineering and Health Studies
https://lio1.tci-thaijo.org/index.php/sehs
ISSN (Online): 2630-0087

Effect of Ruesi Dadton on vital capacity, flexibility and range of motion in healthy elderly individuals

Phaksachiphon Khanthong[1], Ananya Dechakhamphu[1] and Amornrat Natason[2]*

[1] Faculty of Thai Traditional and Alternative Medicine, Ubon Ratchathani Rajabhat University, Ubon Ratchathani 34000, Thailand
[2] Faculty of Nursing, Ubon Ratchathani University, Ubon Ratchathani 34190, Thailand

[*] ***Corresponding author***:
Phaksachiphon Khanthong
phaksachiphonk@gmail.com

Received: *8 June 2021*
Revised: *4 July 2021*
Accepted: *13 October 2021*
Published: *2 June 2022*

Citation:
Khanthong, P., Dechakhamphu, A., and Natason, A. (2022). Effect of Ruesi Dadton on vital capacity, flexibility and range of motion in healthy elderly individuals. Science, Engineering and Health Studies, 16, 22050003.

ABSTRACT

Pulmonary function and physical performance decrease with age, resulting in an increase in morbidity and mortality in the elderly. Ruesi Dadton (RD) combines various protocols for health promotion suitable for all ages, including deep breathing and stretching. The aims of this quasi-experimental study were to investigate the effectiveness of RD on vital capacity and the physical performance in healthy elderly individuals after 4 and 12 weeks in pre-post intervention. Twenty-three participants were instructed to perform RD for 60 min, 3 times/week over a 12-week period. Measurement tools included spirometry device, a sit-and-reach (SR) box, and a goniometer to measure vital capacity (VC), which flexibility and range of motion were assessed. All parameters showed significant improvement. SR and shoulder flexion improved at all measurement time-points. VC and hip extension were significantly different after 12 weeks of RD. Shoulder extension significantly increased after 12 weeks of RD versus that at baseline and the 4-week timepoint. Hip flexion significantly improved from baseline to the 12-week timepoint. However, there was no change in shoulder abduction. Thus, it is recommended that the use of RD for health promotion may improve respiratory and musculoskeletal function in healthy elderly individuals.

Keywords: exercise; elderly; flexibility; range of motion; vital capacity

1. INTRODUCTION

According to the Department of Older Persons (2021) statistics, 17.57 percent of 60-year-old populations are predicted to enter an aged society by the end of 2021, which equates to more than 20% of the population aged 60 and over. It is critical to prepare health care promotion and prevention strategies for the rapidly growing super aged society. Regular physical activity is important for the prevention of health problems, particularly geriatric syndrome (Sanford et al., 2020). In a survey conducted with expert geriatricians from Asia-Pacific, more than 90% of the experts established the following categories as components of geriatric syndrome: dementia, falls, immobility, and frailty (Won et al., 2013).

Elderly people face problems that are more complex in nature than those experienced by younger people, particularly with regard to pulmonary function. Chronic respiratory-related diseases are a major cause of mortality in the elderly (Ezzati et al., 2008). Vital capacity (VC) is a more accurate predictor of death in adults and the elderly than body mass index and blood pressure (Gupta and Strachan, 2017). Moreover, changes in body composition are associated with pulmonary function in the elderly (Lim et al., 2011), while increasing age is related to decreased chest expansion, respiratory muscle strength, and pulmonary function (Dyer, 2012; Sharma and Goodwin, 2006). Reduced reserve volume is a common occurrence in the elderly because aging affects the respiratory system and impairs structural, physiological, and immunological

functions (Sharma and Goodwin, 2006).

As regards physical function, loss of hydration and elasticity are common problems in the elderly that lead to lack of flexibility and restricted movement, especially kyphosis in those aged 70 years and over (Oyarzún, 2009). According to a survey, 21% of the elderly population had shoulder problems (Chard et al., 1991), whereas the limited range of motion (ROM) in lower limbs was associated with fall injuries (Chiacchiero et al., 2010). Gait patterns in the elderly can be improved by increasing lower limb flexibility (Watt et al., 2011). The decrease in upper and lower limb flexibility affects physical performance in the elderly and can lead to disability (George et al., 2002). Moreover, older age is associated with decreased physical activity and physical performance (Milanović et al., 2013).

Reusi Dadton (RD) or Thai yoga combines many types of exercises and is categorized as a mind-body intervention similar to yoga and tai chi. RD has been found to significantly improve respiratory muscle strength in healthy females (Chidnok et al., 2007) and handgrip strength in the elderly (Khanthong et al., 2021). However, no study has been conducted on the effect of RD on pulmonary function or the respiratory system in the elderly. Studies on flexibility after RD practice in elderly have reported conflicting results between immediate and long-term effects (Khanthong et al., 2019; Aiemong et al., 2018; Noradechanunt et al., 2017; Widjaja et al., 2021; Wattanathorn et al., 2012). When compare RD and tai chi, significant improvement in the flexibility of individuals practicing RD was noted (Noradechanunt et al., 2017). Furthermore, a meta-analysis of RD's impact on the ROM showed that shoulder extension and abduction are significantly improved following RD (Kongkaew et al., 2018). However, significant differences were found in other joints, but not in the elderly (Tanasugarn et al., 2015; Thonglong and Rattanathantong, 2017).

The key to future success in a super-aged society is to promote elderly independence. In general, RD effect on flexibility in the elderly is possible, but its effect on ROM is still unknown, and there is no evidence to investigate a VC. Based on the movement and characteristics of RD, we hypothesize that elderly individuals who continue to practice RD can improve their flexibility, range of motion, and also their chest expanding capacity through breathing exercises. Therefore, this study aimed to investigate the effects of VC, flexibility, and ROM of shoulder and hip joints in healthy elderly individuals for 12 weeks of pre-post assessment at 4 and 12 weeks.

2. MATERIALS AND METHODS

2.1 Study design

A quasi-experimental study was used to compare the difference in the VC, sit-and-reach (SR) test, and ROM (shoulder and hip) in healthy elderly individuals practicing RD over a 12-week period; assessments were performed at baseline, 4 weeks, and 12 weeks. This study was conducted at the Nong-Lai Health Promoting Hospital, Ubon Ratchathani Province, Thailand. The study protocol was registered in the Thai Clinical Trials Registry (No. TCTR20200730004).

2.2 Participants and procedure

Ninety-seven participants were recruited between January and April 2018. The screening criteria and sample size calculations were performed as per a previous study (Natason et al., 2020; Khanthong et al., 2022). The exclusion criteria were the presence of congenital diseases, severe infectious diseases, injury in the past 3 months, or spine problems; plan for a hospital admission; and the presence of current severe medical conditions for which exercise was contraindicated. In total, 27 participants met the criteria. Only 23 participants were included as four participants were excluded due to loss of data from two interventions and two assessments (Figure 1). The eligible participants were aged 60-89 years and gave written informed consent. The study was approved by the Ethics Committee for Research in Human Subjects in the Fields of Thai Traditional and Alternative, Thai Ministry of Public Health approved the study (No. 07-2556).

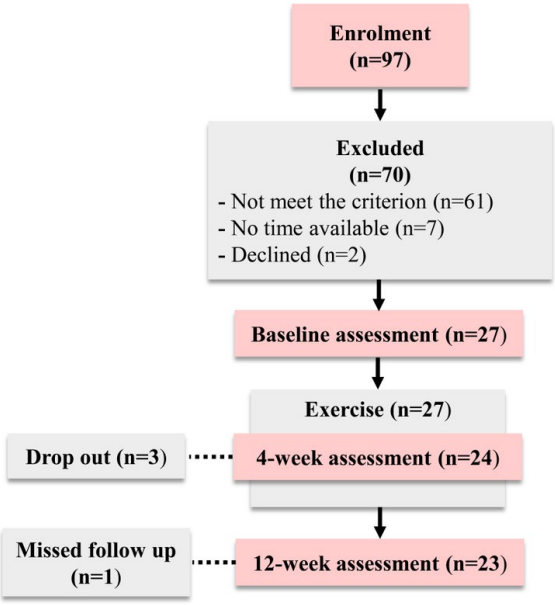

Figure 1. Quasi-experimental study flow (n=23)

The first assessment at baseline was performed prior to the demonstration of RD. Four hours of RD breathing, RD performing, and a full protocol of RD with breathing were performed at the demonstration before the exercise program began. The RD program was conducted three times a week. An experienced physical therapist with more than 10 years of experience (PK) supervised the RD protocol with a supplementary video. Six research assistants led the RD protocol and coached the small group of participants under PK's supervision.

2.3 Exercise

Participants were instructed to participate in a group exercise 12-week RD protocol for 60 min/week, totaling 36 sessions at the Nong-Lai Health Promoting Hospital. The following fifteen postures obtained from the Thai Ministry of Public Health (Subcharoen, 2013) were applied in this study: 1) facial massage, which comprised seven techniques; 2) wrist discomfort; 3) stomach ache and headache; 4) headache and blurred eyes; 5) upper limb discomfort; 6) lower limb massage; 7) chronic muscular discomfort; 8) upper limb trouble; 9) for longevity; 10) trunk, knee, and leg trouble; 11) chest trouble; 12) hand and foot numbness; 13) lower back and leg discomfort; 14)

chest and body discomfort; and 15) hand and foot weakness (Figure 2). Five repetitions were performed in each posture. The participants were encouraged to take slow deep breaths in and out throughout the program

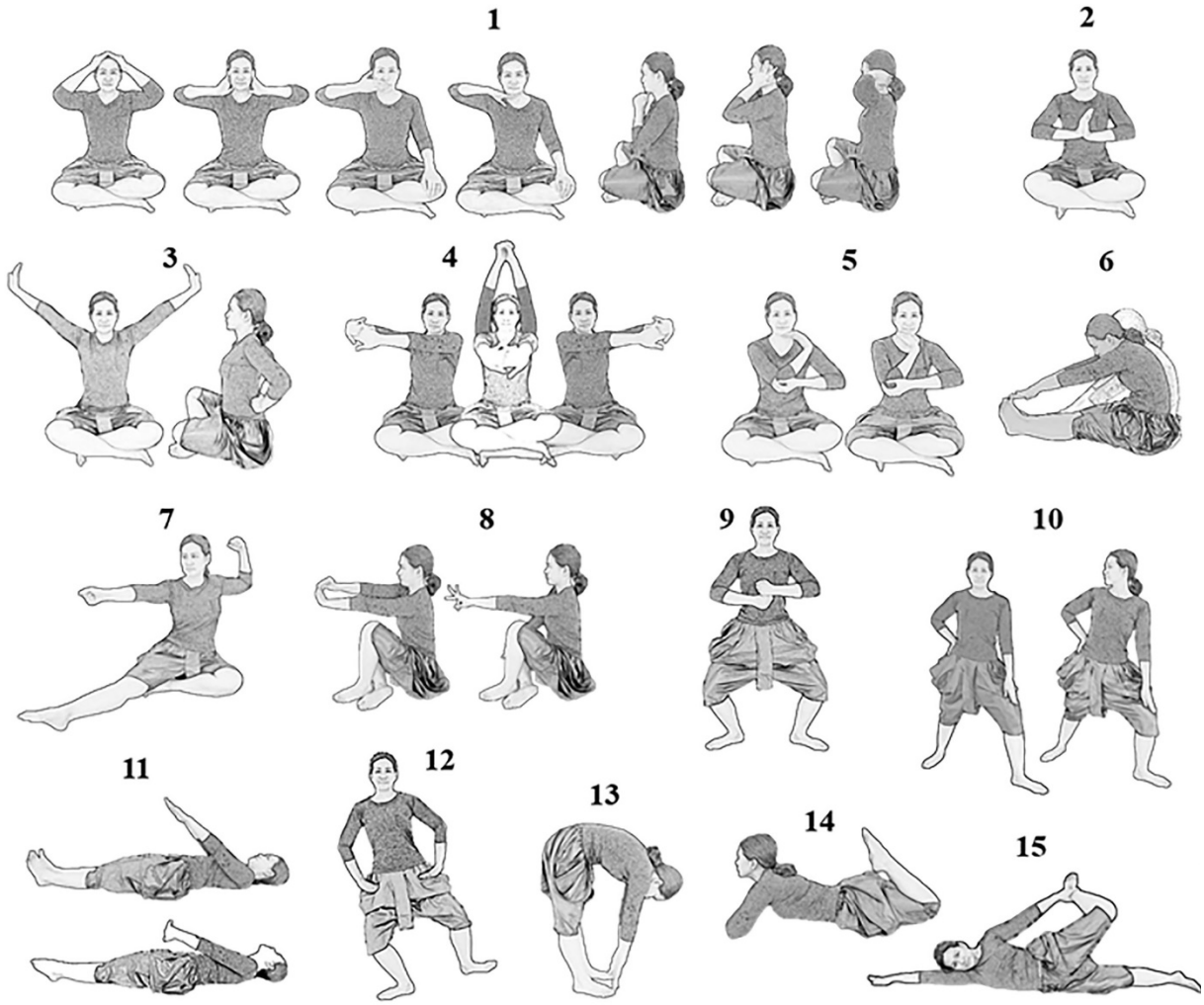

Figure 2. A total of fifteen Ruesi Dadton (RD) postures from the Thai Ministry of Health

2.4 Outcome measurement

Each station had two assessors: one major assessor and one assistant. There were primary and secondary outcomes. The primary outcome was the pulmonary function and the secondary outcome was the physical performance including flexibility and ROM.

2.4.1 Primary outcome

2.4.1.1 Pulmonary function

A portable spirometer (Riester spirotest 5260, Riester Com., Jungingen, Germany) was used to evaluate pulmonary function. The protocol manoeuvre followed the instruction of the American Thoracic Society Guideline (Graham et al., 2019). The participants were instructed to sit on a chair, hold a mouthpiece, and pinch their nose with their fingers. The value recorded between maximum inspiration and maximum expiration was noted as the VC or expiratory VC. The maximum result from three attempts with a 2-min rest between rounds was selected for analysis.

2.4.2 Secondary outcome

2.4.2.1 Flexibility

Two assistants evaluated the SR test by instructing participants to undertake a long sitting position with the knees kept straight to reach the sides of the SR box with their hands and moving their hands away as far as possible and maintaining that position for 2 s (Lemmink et al., 2003; Wells and Dillon, 1952). This manoeuvre was used to measure back and leg flexibility and has been shown to have high validity and reliability (Wells and Dillon, 1952). A maximum of three recordings was taken with a 2-min rest in between each recording.

2.4.2.2 ROM

PK and assistants, measured shoulder and hip in active ROM of the dominant side using a goniometer. The shoulder joint was measured in three directions: flexion, extension, and abduction; the hip joint was measured in two directions: flexion and extension. While sitting on a chair without a backrest, shoulder extension and shoulder

abduction were measured; shoulder flexion and hip flexion were measured with the participant in a supine position, while hip extension was measured while the participant was lying on their side (Soucie et al., 2011). Each direction was measured three times and the result with the highest value was used in the calculation.

2.5 Data analysis

Data were analyzed using IBM SPSS Statistics (version 17.0; SPSS Inc., Chicago, IL, USA), and significance was set at 0.05. The baseline characteristics of the participants presented as descriptive statistics. A repeated-measures analysis of variance was used to compare the measured values between the following 3 points: baseline and 4 weeks, baseline and 12 weeks, and 4 weeks and 12 weeks. Match paired analysis was performed with the Wilcoxon signed-rank test to detect significant difference.

3. RESULTS

3.1 Baseline characteristics

The characteristics of twenty-three participants are shown in Table 1. The majority of participants were female, aged below 70 years, and had finished primary school. The cut-off point for body mass index was according to the World Health Organization guidelines expert consultation for Asians and the elderly (Bahat et al., 2012; WHO Expert Consultation, 2004). There was no difference with respect to occupation. With respect to exercise, exercise performed at least once a week was recorded. Most respondents answered that they walked to their destination (the temple) twice, once in the morning and once following the monk's meal at midday. This was more commonly done than just walking for exercise (general walking). However, 17.4% of the participants reported sedentary lifestyles.

3.2 Pulmonary function

VC improved significantly at both 4 and 12 weeks from baseline (p<0.05), but there was no significant change in this parameter between 4 and 12 weeks of RD (Figure 3).

3.3 Flexibility

For SR (Figure 4), an increase in flexibility was seen at all three time points assessed: between baseline and 4 weeks, baseline and 12 weeks, and 4 weeks and 12 weeks of performing RD.

3.4 ROM

All ROM directions are shown in Figure 5 (shoulder flexion, shoulder extension, shoulder abduction, hip flexion, and hip extension). The mobility of shoulder and hip ROM was significantly different, except for shoulder abduction. Shoulder flexion was highlighted in the study because it revealed highly significant improvements at all three time points (p<0.05). There was no significant difference after 4 weeks of performing RD, but there was a difference after 12 weeks and between the 4-week and 12-week RD period for shoulder extension. Hip flexion only showed a significant improvement 12 weeks after RD. Lastly, there was a significant improvement in hip extension after 4 and 12 weeks, while a minimal change was observed in this regard when comparing outcomes after 4 and 12 weeks of performing RD.

Table 1. Characteristics of the participants, both in terms of number and percentage (n=23)

Variables		Number	%
Sex	Female	19	82.6
Age	60-64 y	12	52.2
	65-69 y	10	43.5
	>70 y	1	4.3
Religious	Buddhism	23	100.0
Occupation	Unemployed	12	52.2
	Farmer	11	47.8
Education	Primary school	21	91.3
	Secondary school	2	8.7
BMI	Underweight (<18.5 kg/m^2)	2	8.7
	Normal (18.5-<25kg/m^2)	11	47.8
	Overweight (25-<30kg/m^2)	10	43.5
Exercise	Walking	10	43.5
	Jogging	5	21.7
	Other	4	17.4
	None	4	17.4

Note: y = year, kg = kilogram, m = meter

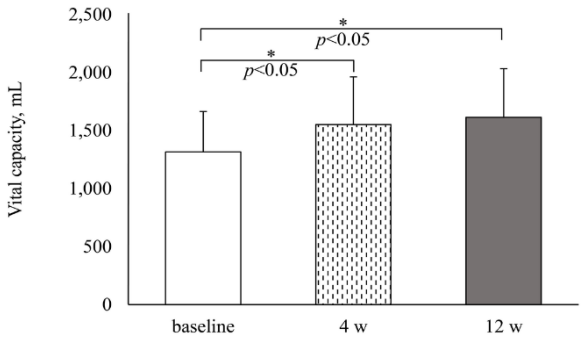

Figure 3. Vital capacity measured by spirometer at baseline, 4-week (4 w), and 12-week (12 w) of Ruesi Dadton (n=23)
Note: Significant differences in the Wilcoxon signed-rank test at p<0.05 (*) were observed 4 and 12 weeks after baseline.

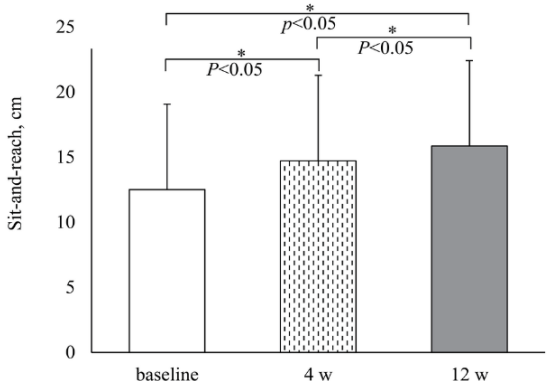

Figure 4. Flexibility as measured by the sit-and-reach test at baseline, 4-week (4 w), and 12-week (12 w) of Ruesi Dadton (n=23)
Note: Significant differences with Wilcoxon signed-rank test at p<0.05 (*) were observed 4 and 12 weeks after baseline.

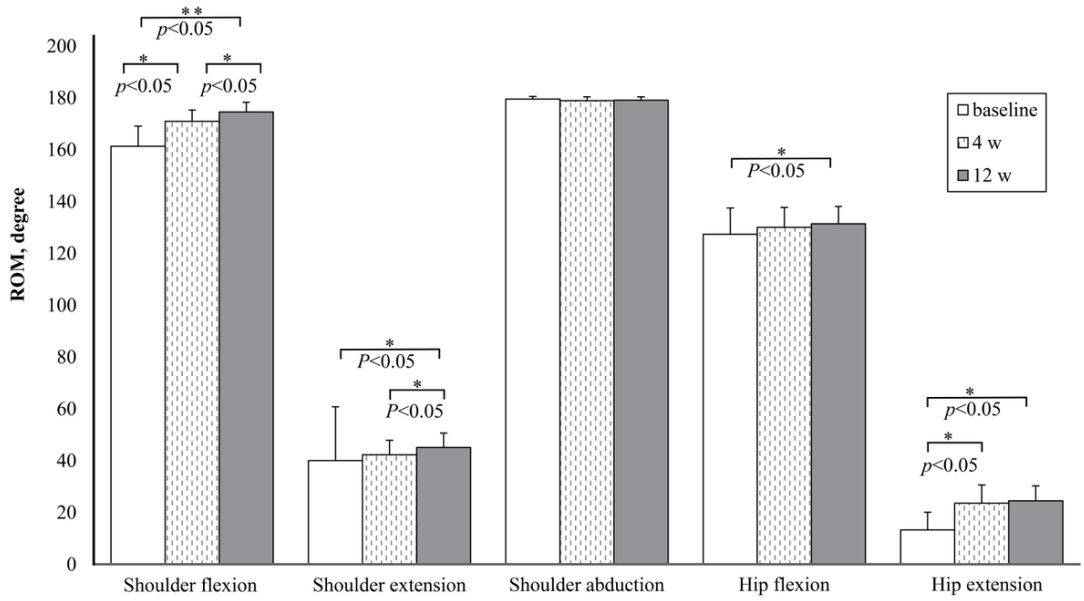

Figure 5. Range of motion measurements of the shoulder flexion, extension, abduction, hip flexion, and extension using a goniometer at baseline, 4-week (4 w), and 12-week (12 w) of Ruesi Dadton (n=23)
Note: Significant differences with Wilcoxon signed-rank test at $p<0.05$ (*) were observed in shoulder flexion (all time points measurement), in hip extension (4 and 12 w after baseline and between 4 and 12 w), in shoulder extension (12 w after baseline and between 4 and 12 w) and in hip flexion (12 w after baseline).

4. DISCUSSION

The study of the effect of the 12-week RD programme on pulmonary function, flexibility, and ROM showed significant difference in healthy elderly individuals, with the exception of shoulder abduction, which showed no change.

At baseline, the mean VC was 1,315.93 mL, which is within the previously reported range of 1,400-2,200 mL in females and males (Pimboon et al., 2021; Pavlica et al., 2010). The average VC was slightly lower than that reported in previous studies because most participants were female. This result was supported by a recent study showing that RD significantly improved respiratory muscle function (Chidnok et al., 2007). However, only RD posture number 11 (in Figure 1; chest trouble posture) was performed, and only time points were investigated. However, the results correlated with other mind-body intervention practices such as yoga (Santaella et al., 2011), tai chi (Hua et al., 2016; Lu and Kuo, 2012), and mixed mind-body intervention (Pimboon et al., 2021; Ross et al., 2019). Additionally, there was a significant difference in pulmonary function after 12 weeks of tai chi (Hua et al., 2016), but forced expiratory volume in the first second and forced VC did not improve (Lu and Kuo, 2012). Moreover, 16 weeks of yoga in the elderly improved the pulmonary function significantly (Santaella et al., 2011), although a shorter duration (4 and 12 weeks) was not found to lead to significant improvement (Fan and Chen, 2011; Chen and Tseng, 2008). Furthermore, a combination of qigong, tai chi, and yoga improved VC after 8 weeks, but not after 4 weeks (Pimboon et al., 2021). In total, mind-body intervention can improve respiratory system function. From the limited number of studies on the effect of mind-body intervention on pulmonary function, RD appears to improve pulmonary function after a shorter duration (4 weeks) than other exercise programs. Additionally, because of supervision and coaching in small groups during the exercise program, participants maintained the correct posture and were encouraged to perform deep breathing, which improved pulmonary function.

Many RD studies have reported contrasting results with regard to flexibility as determined by the SR test. The findings were consistent with those reported previously (Khanthong et al., 2019; Noradechanunt et al., 2017; Thonglong and Rattanathantong, 2017; Pongnaratorn, 2015) and inconsistent with some other findings (Aiemong et al., 2018; Widjaja et al., 2021; Wattanathorn et al., 2012). A recent study on 12 weeks of tai chi showed that flexibility did not improve in older healthy Japanese adults (Takeshima et al., 2017); however, it improved in patients with fibromyalgia (Wong et al., 2018). However, for yoga, there was improved flexibility after 10 to 12 weeks (Fan and Chen, 2011; Gothe and Mcauley, 2016; Bhaskar, 2021). Therefore, RD and yoga strongly increased flexibility. The reason for the differing results between healthy individuals and those with diseases could be because: 1) healthy individuals have normal flexibility before exercise; therefore, no significant difference was found; 2) there are diseases such as obesity that limit flexibility of the abdomen rather than tightening of the hamstring; 3) the limitation in ROM of some joints may influence SR performance (Shephard et al., 1990); and 4) an increase in the SR score may not be due to hamstring or back flexibility, and SR can improve the mobility of other joints (shoulder and hip). Additionally, this manoeuvre was found to have higher accuracy for the hamstring than for the back in the elderly (Lemmink et al., 2003; Mayorga-Vega et al., 2014). However, this interpretation should be considered a limitation of this test, but it is still simple and reliable enough to measure general flexibility (Shephard et al., 1990).

The ROM was more specific in terms of direction of the joints than the SR; however, more expert manoeuvres are required. The shoulder extension was slightly higher than the normal range (45°), which might be because of incomplete inhibition of participants' compensations. However, a practice test was carried out before the study was performed until the validity reached over 0.8. A previous study on RD demonstrated that RD could increase ROM in all directions in healthy individuals (Thonglong and Rattanathantong, 2017; Tanasugarn et al., 2015; Kongkaew et al., 2018). After office workers performed 4 days of RD, shoulder flexion was found to increase (Tanasugarn et al., 2015). Moreover, it significantly improved shoulder and hip ROM for flexion and extension in female university students (Thonglong and Rattanathantong, 2017). Furthermore, there was consistency between RD and yoga in elevating ROM with regard to shoulder flexion, shoulder abduction, hip flexion, and hip extension after 4 weeks (Fan and Chen, 2011; Chen and Tseng, 2008; Gonçalves et al., 2011). However, no study on tai chi has been reported because this form tends to promote other effects such as balance and muscular strength, rather than ROM improvement. Shoulder abduction findings in this case were limited as participants had a normal range at baseline; therefore, we could not definitively report any change.

To the best of our knowledge, this is the first study assessing the effect of RD on lung function in the elderly. However, this study has several limitations. First, there was set as a pre-post assessment without controls. Second, the sample size was relatively small in comparison to the size of the population. Finally, the participants were not classified into groups equally based on characteristics such as sex. Thus, interpretation of the results should be made taking into consideration these limitations. Further studies should include control groups and a larger sample size. Specific RD postures for individual diseases or syndromes might be a challenge in terms of comparing the efficacy of specific pulmonary function in elderly individuals.

5. CONCLUSION

The results suggested that performing RD has the potential to improve respiratory and musculoskeletal function in elderly individuals over a short period (4 weeks), gradually leading to long-term improvement. There were a few limitations to this study, including small sample size and the absence of a control group. Randomized controlled trial and comparisons to other mind-body interventions are recommended for future research.

ACKNOWLEDGMENTS

This study was supported and funded by the Thai Traditional Medical Knowledge Fund, Department of Thai Traditional and Alternative Medicine, Development of Thai People Project, Faculty of Medicine, Thai Ministry of Public Health (No. 11/2560).

REFERENCES

Aiemong, R., Konguan, W., Kanokvalaiwan, S., Vannajak, P. T., and Vannajak, K. (2018). The immediate and short term effects of dynamic sitting exercise and Rusie Dutton on trunk flexibility in healthy sedentary. *The Public Health Journal of Burapha University*, 13(1), 1-10. [in Thai]

Bahat, G., Tufan, F., Saka, B., Akin, S., Ozkaya, H., Yucel, N., Erten, N., and Karan, M. A. (2012). Which body mass index (BMI) is better in the elderly for functional status? *Archives of Gerontology and Geriatrics*, 54(1), 78-81.

Bhaskar, V. (2021). Effect of suryanamaskar on functional mobility, functional reach and trunk flexibility of elderly men. *International Journal of Physiology, Nutrition and Physical Education*, 6(1), 94-98.

Chard, M. D., Hazleman, R., Hazleman, B. L., King, R. H., and Reiss, B. B. (1991). Shoulder disorders in the elderly: a community survey. *Arthritis and Rheumatism*, 34(6), 766-769.

Chen, K. M., and Tseng, W. S. (2008). Pilot-testing the effects of a newly-developed silver yoga exercise program for female seniors. *Journal of Nursing Research*, 16(1), 37-46.

Chiacchiero, M., Dresely, B., Silva, U., DeLosReyes, R., and Vorik, B. (2010). The relationship between range of movement, flexibility, and balance in the elderly. *Topics in Geriatric Rehabilitation*, 26(2), 148-155.

Chidnok, W, Weerapun O, Wasuntarawat C, Lertsinthai P, and Sripariwuth, E. (2007). Effects of Ruesi Dadton (hermit training) on muscle strength, respiration and exercise performance in females. *Thai Journal of Physical Therapy*, 27(3), 126- 136.

Department of Older Persons. (2021). Statistics of the elderly in Thailand, 77 provinces as of December 31, 2020. [Online URL: //www.dop.go.th/th/know/side/1/1/335] accessed on March 11, 2021. [in Thai]

Dyer, C. (2012). The interaction of ageing and lung disease. *Chronic Respiratory Disease*, 9(1), 63-67.

Ezzati, M., Friedman, A. B., Kulkarni, S. C., and Murray, C. J. (2008). The reversal of fortunes: trends in county mortality and cross-county mortality disparities in the United States. *PLoS Medicine*, 5(4), e66.

Fan, J. T., and Chen, K. M. (2011). Using silver yoga exercises to promote physical and mental health of elders with dementia in long-term care facilities. *International Psychogeriatrics*, 23(8), 1222-1230.

George, J. H., Kiyoji, T., Ryosuke, S., and Masaki, N. (2002). Flexibility and physical functions of older adults: a review. *Journal of Aging and Physical Activity*, 10(2), 169-206.

Gonçalves, L. C., Vale, R. G. d. S., Barata, N. J. F., Varejão, R. V., and Dantas, E. H. M. (2011). Flexibility, functional autonomy and quality of life (QoL) in elderly yoga practitioners. *Archives of Gerontology and Geriatrics*, 53(2), 158-162.

Gothe, N. P., and McAuley, E. (2016). Yoga is as good as stretching–strengthening exercises in improving functional fitness outcomes: results from a randomized controlled trial. *The Journals of Gerontology: Series A*, 71(3), 406-411.

Graham, B. L., Steenbruggen, I., Miller, M. R., Barjaktarevic, I. Z., Cooper, B. G., Hall, G. L., Hallstrand, T. S., Kaminsky, D. A., McCarthy, K., McCormack, M. C., Oropez, C. E., Rosenfeld, M., Stanojevic, S., Swanney, M. P., and Thompson, B. R. (2019). Standardization of spirometry 2019 update An official American thoracic society and European respiratory society technical statement.

American Journal of Respiratory and Critical Care Medicine, 200(8), 70-88.

Gupta, R. P., and Strachan, D. P. (2017). Ventilatory function as a predictor of mortality in lifelong non-smokers: evidence from large British cohort studies. *BMJ Open*, 7(7), e015381.

Hua, Y., Xiaojuan, R., Yuefeng, W., Ying, Z., and Hongmei, D. (2016). An empirical study on the effect of tai chi exercise on the physical and mental health of the elderly based on network data. *Revista Ibérica de Sistemas e Tecnologias de Informação*, 13(12), 219-227.

Khanthong, P., Natason, A., and Dechakhamphu, A. (2022). Benefit of Ruesi Dadton on oxidative stress and physical performance: quasi-experimental study. *Physical and Occupational Therapy in Geriatrics,* 40(1), 79-93.

Khanthong, P., Sriyakul, K., Dechakhamphu, A., Krajarng, A., Kamalashiran, C., and Tungsukruthai, P. (2021). Traditional Thai exercise (Ruesi Dadton) for improving motor and cognitive functions in mild cognitive impairment: a randomized controlled trial. *Journal of Exercise Rehabilitation,* 17(5), 331-338.

Khanthong, P., Suktho, S., Panthprohm, S., Thaenhom, K., and Rahan, W. (2019). The immediate effects of individual thai yoga on back flexibility in the elderly. *UBRU Journal for Public Health Research*, 7(2), 108-114. [in Thai]

Kongkaew, C., Lertsinthai, P., Jampachaisri, K., Mongkhon, P., Meesomperm, P., Kornkaew, K., and Malaiwong, P. (2018). The effects of Thai yoga on physical fitness: A meta-analysis of randomized control trials. *Journal of Alternative and Complementary Medicine*, 24(6), 541-551.

Lemmink, K. A. P. M., Kemper, H. C. G., Greef, M. H. G., Rispens, P., and Stevens, M. (2003). The validity of the sit-and-reach test and the modified sit-and-reach test in middle-aged to older men and women. *Research Quarterly for Exercise and Sport*, 74(3), 331-336.

Lim, S., Kwon, S. Y., Yoon, J. W., Kim, S. Y., Choi, S. H., Park, Y. J., Yoon, H. I., Chang, Y. S., Lee, J. H., Lee, C. T., Kim, K. W., Park, K. S., and Jang, H. C. (2011). Association between body composition and pulmonary function in elderly people: the Korean longitudinal study on health and aging. *Obesity*, 19(3), 631-638.

Lu, W. A., and Kuo, C. D. (2012). Effect of 3-month tai chi chuan on heart rate variability, blood lipid and cytokine profiles in middle-aged and elderly individuals. *International Journal of Gerontology*, 6(4), 267-272.

Mayorga-Vega, D., Merino-Marban, R., and Viciana, J. (2014). Criterion-related validity of sit-and-reach tests for estimating hamstring and lumbar extensibility: a meta-analysis. *Journal of Sports Science & Medicine*, 13(1), 1-14.

Milanović, Z., Pantelić, S., Trajković, N., Sporiš, G., Kostić, R., and James, N. (2013). Age-related decrease in physical activity and functional fitness among elderly men and women. *Clinical Interventions in Aging*, 8, 549-556.

Natason, A., Khanthong, P., and Dechakhamphu, A. (2020). The effect of Rueseedutton exercise postures on nutritional status and quality of life in older people. *Ramathibodi Nursing Journal*, 26(1), 90-106.

Noradechanunt, C., Worsley, A., and Groeller, H. (2017). Thai Yoga improves physical function and well-being in older adults: a randomised controlled trial. *Journal of Science and Medicine in Sport*, 20(5), 494-501.

Oyarzún, G. M. (2009). Pulmonary function in aging. *Revista Medica de Chile*, 137(3), 411-418.

Pavlica, T., Bozic-Krstic, V., and Rakic, R. (2010). Correlation of vital lung capacity with body weight, longitudinal and circumference dimensions. *Biotechnology & Biotechnological Equipment*, 24, 325-328.

Pimboon, B., Supaporn, S., and Peepathum, P. (2021). Effects of qigong, tai chi and yoga training on balance and physical fitness in elderly females. *Christian University Journal*, 27(1), 97-109. [in Thai]

Pongnaratorn, P. (2015). The effects of applied Ruesi Datton exercise on movement and flexibility of the back in low back pain patients. *Journal of Thai Traditional & Alternative Medicine*, 13(3), 247-257. [in Thai]

Ross, R., Goodpaster, B. H., Koch, L. G., Sarzynski, M. A., Kohrt, W. M., Johannsen, N. M., Skinner, J. S., Castro, A., Irving, B. A., Noland, R. C., Sparks, L. M., Spielmann, G., Day, A. G., Pitsch, W., Hopkins, W. G., and Bouchard, C. (2019). Precision exercise medicine: understanding exercise response variability. *British Journal of Sports Medicine*, 53(18), 1141-1153.

Sanford, A. M., Morley, J. E., Berg-Weger, M., Lundy, J., Little, M. O., Leonard, K., and Malmstrom, T. K. (2020). High prevalence of geriatric syndromes in older adults. *PLoS ONE*, 15(6), e0233857.

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

Sharma, G., and Goodwin, J. (2006). Effect of aging on respiratory system physiology and immunology. *Clinical Interventions in Aging*, 1(3), 253-260.

Shephard, R. J., Berridge, M., and Montelpare, W. (1990). On the generality of the "sit and reach" test: an analysis of flexibility data for an aging population. *Research Quarterly for Exercise and Sport*, 61(4), 326-330.

Soucie, J. M., Wang, C., Forsyth, A., Funk, S., Denny, M., Roach, K. E., Boone, D., and Hemophilia Treatment Center Network (2011). Range of motion measurements: reference values and a database for comparison studies. *Haemophilia*, 17(3), 500-507.

Subcharoen, P. (2013). *Rue Si Dat Ton*, 1st, Bangkok: Post publishing, Department of Thai Traditional and Alternative Medicine, pp. 1-76.

Takeshima, N., Islam, M. M., Kato, Y., Koizumi, D., Narita, M., Kitabayashi, Y., Rogers, N. L., and Rogers, M. E. (2017). Effects of 12 weeks of tai chi chuan training on balance and functional fitness in older Japanese adults. *Sports*, 5(2), 32.

Tanasugarn, L., Natearpha, P., Kongsakon, R., Chaosaowapa, M., Choatwongwachira, W., Seanglaw, D., Kiratisin, P., Namatra, C., Srinonprasert, V., Nimmannnit, A., Vannabhum, M., Laohapand, T., and Kuptniratsaikul, V. (2015). Physical effects and cognitive function after exercising "Rue-si-dad-ton" (exercise using the posture of the hermit doing body contortion): a randomized controlled pilot trial. *Journal of the Medical Association of Thailand*, 98(3), 306-313.

Thonglong, T., and Rattanathantong, K. (2017). Effects of traditional Thai hermit's exercise or Ruesi Dudton on flexibility and range of motion in female university

students. *Thai Pharmaceutical and Health Science Journal*, 12(3), 129-132.

Watt, J. R., Jackson, K., Franz, J. R., Dicharry, J., Evans, J., and Kerrigan, D. C. (2011). Effect of a supervised hip flexor stretching program on gait in elderly individuals. *Randomized Controlled Trial*, 3(4), 324-329.

Wattanathorn, J., Boonterm, T., Thukhummee, W., Muchimapura, S., Wannanon, P., Kaewbutra, S., Chinnabut, W., Chaisiwamongol, K., and Kaewkaen, P. (2012). Evaluation of Thai style stretching exercise on "Ruesi Dud Ton" on physical health and oxidative stress in healthy volunteer. *OnLine Journal of Biological Sciences*, 12(4), 134-141.

Wells, K. F., and Dillon, E. K. (1952). The sit and reach—A test of back and leg flexibility. American Association for Health, *Physical Education and Recreation*, 23(1), 115-118.

Widjaja, W., Wongwattanapong, T., Laskin, J. J., and Ajjimaporn, A. (2021). Benefits of Thai yoga on physical mobility and lower limb muscle strength in overweight/obese older women: a randomized controlled pilot trial. *Complementary Therapies in Clinical Practice*, 43, 101345.

Won, C. W., Yoo, H. J., Yu, S. H., Kim, C. O., Dumlao, L. C. I., Dewiasty, E., Rowland, J., Chang, H. H., Wang, J., Akishita, M., Tan, T. L., Lum, C., and Prakash, O. (2013). Lists of geriatric syndromes in the Asian-Pacific geriatric societies. *European Geriatric Medicine*, 4(5), 335-338.

Wong, A., Figueroa, A., Sanchez-Gonzalez, M. A., Son, W. M., Chernykh, O., and Park, S. Y. (2018). Effectiveness of tai chi on cardiac autonomic function and symptomatology in women with fibromyalgia: a randomized controlled trial. *Journal of Aging and Physical Activity*, 26(2), 214-221.

World Health Organization Expert Consultation. (2004). Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *The Lancet*, 363(9403), 157-163.