POSTURE ANALYSIS USING POSITION DETECTOR DTP2 IN SENESCENT WOMEN AFTER THE APPLICATION OF A TARGETED EXERCISE PROGRAM

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During the years 2005, 2006, and 2007, we studied changes in the posture and spinal shape in three groups of younger female seniors (mean age 61, 63, and 66 years) using the diagnostic device DTP2 following the interventional procedure of a targeted exercise program (the Chinese therapeutic exercise known as "Hui chun gong"). The exercise influenced mainly the pelvic area; the trends suggesting improved posture and stability did not reach statistical significance in all cases. Since the exercise technique is technically difficult, improperly performed positions resulted in a zero effect rather than improvement.

Positive changes were always found in terms of improved stance stability and significant shift of the thoracic kyphosis towards the vertical axis, which suggests improved posture. Shoulder position showed a certain degree of inconsistency in terms of changes in shoulder asymmetry. Pelvic position also responded to the intervention procedures by shifting the asymmetry of the spinal angles after the 1st and 2nd phases of exercise, while a statistically significant offset of the left sided asymmetry was achieved after the 3rd phase. We found a reduced extent of titubation of the axial skeleton, which was evaluated to be an accompanying effect of the improved stance stability. In total, best results were manifested following the intervention in 2007, when the extent of titubation was decreased in the direction of both the x and y axes, a statistically significant positive change was found in the adjustment of symmetry of the posterior superior iliac spine, and a materially significant trend of a decrease in the axial values of lordoses and thoracic kyphosis was observed. The reasons for these changes can be found in an increased emphasis on the proper performance of exercise techniques and thus adjustment of muscle imbalances.

Subjective feelings of the senior patients were very beneficial, as they evaluated very positively the feeling of improved stance stability.

Keywords: Posture, DTP2, women, senescence, targeted exercise program Hui Chun Gong.

INTRODUCTION

Upright posture can be considered to be an individual postural program which came into existence in the course of human evolution. "Bad" posture can usually be seen in individuals lacking the disposition towards variability of postural and motor variations. We can also find it in probands who are forced to assume long term unchanging or repeatedly identical positions in their occupations. Bad posture is usually a source of various functional disorders of the postural system, which, in the case of frequent occurrence, may even lead to structural changes. Clinical pictures of poor bodily posture in the elderly are very diverse. They usually involve disorders of the postural arrangement of the spinal elements with sagittal or lateral axial deviation, displacements of the spinal sectors as compared to the head and support base, kyphotic posture, or disorders associated with rotation. This study is focused on establishing changes in the shape of the spine and in bodily posture before and after the application of therapeutic exercises performed for a period of three and six months in women of early senior age (senescence). We chose a Chinese therapeutic exercise called "Hui chun gong" to correct posture and flexibility. It involves precisely targeted, slowly led movements that are designed to affect the whole body. The exercise is also known as "the rejuvenation exercise of the Chinese emperors" and it is claimed to have considerable therapeutic effects by the non professional public. Imagination and laughter are important to establish mental balance.

OBJECTIVE AND METHOD

The objective of the work was to verify the presumed changes in posture and spine shape using the DTP2 diagnostic device after an intervention procedure of the selected targeted exercise program (Chinese therapeutic exercise). The women exercised in a continuous time sequence of three months during the year 2005 and six months during the years 2006 and 2007. The exercise

was done on a weekly basis for 1½ hours, and in addition the probands observed a home exercise program for at least 15 minutes a day. Once the intervention had been completed, this regular program was no longer followed.

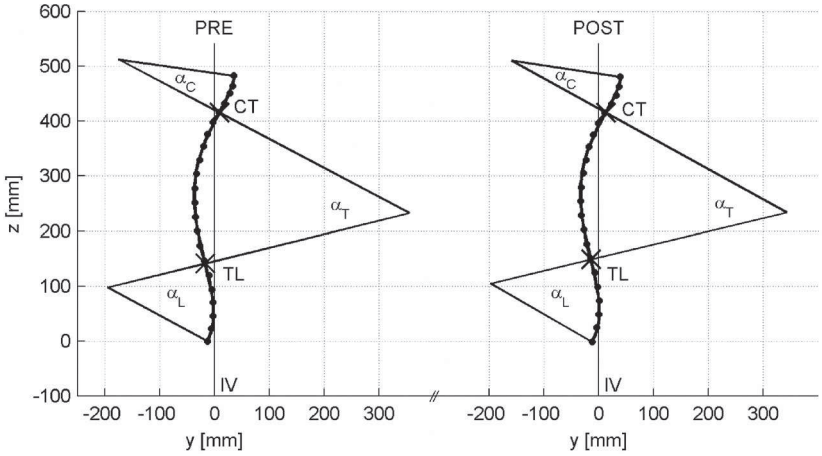
The research group comprised 20 female probands in the year 2005, 23 senior patients in the year 2006 and 21 female probands in the year 2007, who underwent examination at baseline and at the end of the experiment. The exercise was always started by 30 women. The 2006 group included 52, 17% of whom were women who had already exercised in the first year of research. The 2007 group, included 42.86% of women who had already exercised in the second year of research. This communication has the character of a pilot study given the numbers of probands.

Standard anthropometric methods and instrumentation were used for somatometric measurements, while the DTP2 diagnostic system (somatographic method) was used for the examination of spinal shape and body statics.

The DTP2 device was developed in cooperation with the Department of Biomechanics and Technical Cybernetics and the Functional Anthropology and Physiology Department at the FPC PU, Olomouc (Kolisko et al., 1995, 2003, 2005). It enables a graphic and numeric analysis of selected points on the body surface in the 3D Cartesian system of coordinates against the zero vertical axis (the zero vertical axis is a vertical line leading from the centre between the proband's heels). Each of the detected points is thereby determined by three coordinates as follows – x coordinate – sagittal distance of the point from the zero vertical, y coordinate – ventral (dorsal) distance from the zero vertical, z coordinate – height of the point cranially from the first caudally measured points on the spine.

After marking the points on the proband's body, each position in a free stance was measured repeatedly three times. Skin projections of the C_3–L_5 spinous processes were used (22 points). In addition, we measured the position of the acromion as well as the position of the posterior superior iliac spine in the pelvic region. To identify the spinal shape, which is defined by the projection of the marked points against the ideal vertical axis, we determined the mean spinal shape. The latter was used as a basis for determination of the polynomial coefficient of the 6th degree, which expresses the character of the spinal shape curve in the frontal and sagittal plane with a sufficient precision (Krejčí, 2007). To obtain a more precise interpretation of changes in the spinal shape curve in the sagittal plane, we used angle values that characterize the angles of cervical, thoracic, and lumbar segments. An example of the graphic representation is shown in Fig. 1, while data is summarized in TABLE 4.

Fig. 1
Mean angle parameters of spinal shape curves in the sagittal plane – the third stage of examination



Legend:
PRE – examination before the application of the exercise program
POST – examination after the application of the exercise program
● – average position of the spinous process
CT – cervicothoracic junction
TL – thoracolumbar junction
α_C – cervical lordosis angle
α_T – thoracic kyphosis angle
α_L – lumbar lordosis angle
IV – ideal vertical axis

Basic statistical characteristics were used to evaluate mean changes in the spinal shape expressed in quantitative data; differences were tested by a paired t-test at the 0.05 level of significance. The mean values of the defined points provide information on the potential trends of changes in body posture; angular characteristics of the curvature peaks in the sagittal and frontal planes characterize the shape of the sagittal and lateral curvature of the spine; mean standard deviation values of repeated measurements inform about the titubation of the spine.

RESULTS AND DISCUSSION

TABLE 1
Basic statistical characteristics of selected anthropometric parameters in women – examination in the years 2005 (n = 20), 2006 (n = 23), and 2007 (n = 21)

Parameters	Baseline examination		Final examination	
	$\bar{x}_1$	s_1	$\bar{x}_2$	s_2
Age (2005) (n = 20)	61.35	3.87	61.65	3.87
Weight	70.05	8.85	68.95	8.61
Height	163.79	4.49	163.83	4.21
BMI	26.19	3.81	25.77	3.76
Age (2006) (n = 23)	63.26	4.88	63.78	4.87
Weight	66.37	10.20	67.11	10.26
Height	161.90	4.94	161.89	5.02
BMI	25.30	3.97	25.63	3.86
Age (2007) (n = 21)	65.69	4.94	66.06	4.93
Weight	68.00	11.69	68.80	12.11
Height	161.40	3.95	161.30	3.98
BMI	28.06	4.27	26.38	4.37

TABLE 1 shows basic statistical characteristics of selected anthropometric parameters in the group of women of senescent age, obtained during the initial and final examination.

The mean body weight and height of women were within the range of normal values for the Czech population (Bláha et al., 1986). BMI and analysis of body composition indicate a more robust constitution and slight overweight.

We used spinal curves of all the probands in both frontal and sagittal planes to calculate the average spinal curvature. Based on the comparison of the average spinal curvature before and after the application of the targeted exercise program, we observed differences in the position of the x, y, and z points and in stance stability (Fig. 2).

When analyzing the results of research in the year 2005, a significant accentuation of the axial system shift to the left of the zero vertical was found in the frontal region in the case of 65% of probands while no change was observed in the remaining 35%. The average range of ellipses – titubations (SD) – was reduced by 0.7 cm in both the x and y axes (TABLE 2), which falls within the level of an allowed measurement error. The limit of 1.0 mm has been set for a material significance of the difference. In a subjective evaluation the probands emphasized an improvement in their stance stability.

After the completion of the research in 2006, a shift of the spinal curve towards the vertical axis was observed in the frontal plane in 50% of probands, and peak of the thoracic kyphosis also came nearer to the zero vertical axis (22.22% of probands). The average range of titubations increased from the mean 1.1 mm in the x axis and 0.2 mm in the y axis, which – as a matter of fact – is negligible.

The 2007 results are similar to the trends found in the 1st stage of the examination. The range of titubations was reduced by 1.1 mm in the x axis and 0.3 mm in the y axis.

TABLE 2
Changes in standard deviation of the mean range of ellipses – variance from axis x and axis y

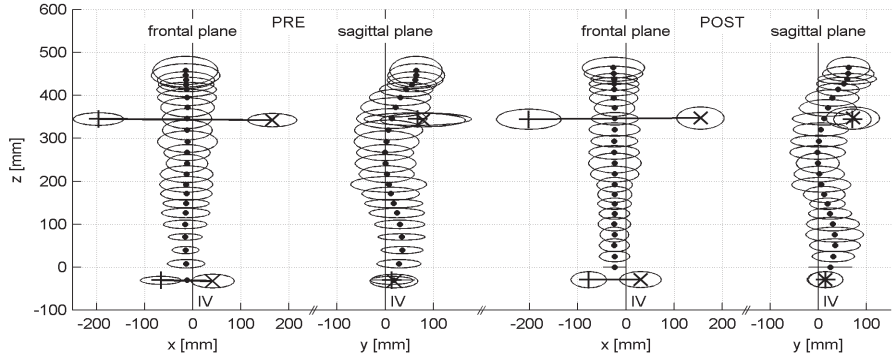
Year	Mean C_3–L_5			
	Pre		Post	
	SDx (mm)	SDy (mm)	SDx (mm)	SDy (mm)
2005	5.2	5.9	4.5	5.2
2006	3.8	5.9	4.9	6.1
2007	4.6	5.7	3.5	5.4

Mean values of changes in acromial and posterior superior iliac spine angles from the horizontal plane laid through these angles are shown in TABLE 3.

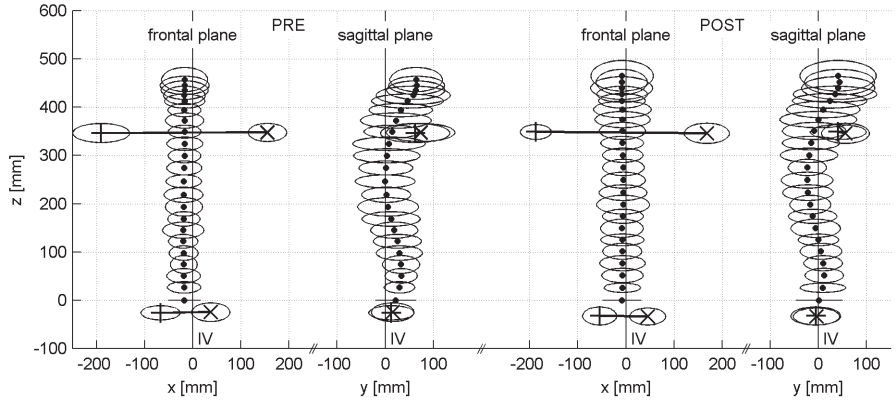
In the frontal plane, we examined a change in the position of acromia and the position of the left and right posterior superior iliac spine compared to the horizontal plane laid through them. Shoulder position was characterized by a certain degree of inconsistency. Mean angle values suggest minor side shifts of shoulder asymmetry (1 degree means approximately 5 mm in the shoulder area and 2 to 3 mm in the pelvic area). During the first stage of research in the year 2005, a statistically significant difference was found involving a shift from left sided asymmetry to right sided asymmetry; the difference after recalculation was approximately 3.15 mm. The position of the pelvis also responded to the intervention procedure in both the 1st and the 2nd phases by shifts in the asymmetry of the spinal angles. After the third phase in the year 2007, we again reported a shift from the left sided asymmetry to the right sided asymmetry in

Fig. 2
Evaluation of the average spinal curvature in the frontal and sagittal planes depicting the stability of the individual points on the spine (ellipses) in the stance (1st to 3rd stage of research, years 2005, 2006, and 2007). Standard deviations (ellipses) are shown in 10 times magnification.

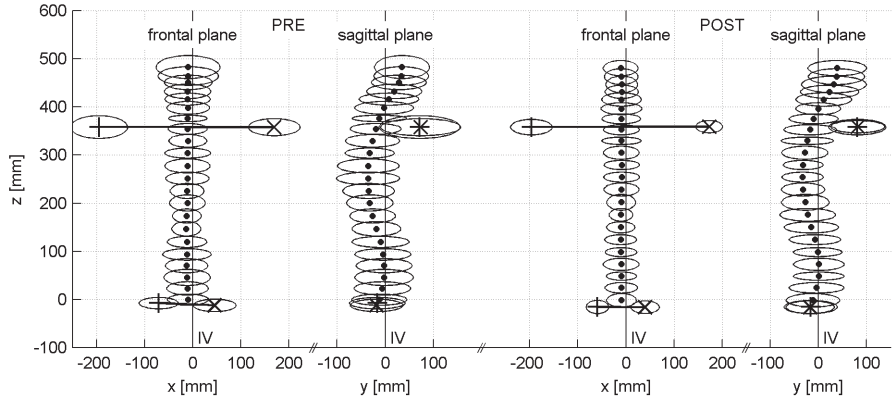
1st stage



2nd stage



3rd stage



Legend:
PRE – examination before the application of the exercise program
POST – examination after the application of the exercise program
\+ – mean position of the left acromion and left posterior superior spine, respectively
× – mean position of the right acromion and right posterior superior spine, respectively
● – mean position of the spinous process
○ – standard deviations of the spinous process (10 times magnification)
IV – ideal vertical axis

TABLE 3
Basic statistical characteristics of the acromial and spinal angles (expressed in degrees)

Year	Acromial angle					Posterior superior spine angle				
	pre		post		dif.	pre		post		dif.
	$\bar{x}$	s	$\bar{x}$	s		$\bar{x}$	s	$\bar{x}$	s	
2005	–0.36	1.36	0.48	1.80	0.86*	–0.80	3.32	0.11	2.27	0.91
2006	0.15	1.75	–0.47	1.93	–0.63*	0.70	2.40	–0.45	2.51	–1.15
2007	–0.03	1.65	0.13	1.55	0.16	–2.35	3.82	–0.23	2.99	2.12*

Note:
Negative value means the left shoulder is higher, while positive value means the right shoulder is higher.

TABLE 4
Mean angular values for cervical and lumbar lordosis and thoracic kyphosis

Year	Cervical lordosis angle α_C			Thoracic kyphosis angle α_T			Lumbar lordosis angle α_L		
	$\bar{x}$ pre	$\bar{x}$ post	dif.	$\bar{x}$ pre	$\bar{x}$ post	dif.	$\bar{x}$ pre	$\bar{x}$ post	dif.
2005	29.83	40.10	10.27*	50.36	51.78	1.43	33.73	31.41	–2.31
2006	43.79	51.57	7.79	53.55	52.66	–0.89	33.29	34.84	1.55
2007	23.08	20.87	–2.21	45.95	45.73	–0.22	45.01	46.06	1.05

the shoulder posture and both a statistically and factually significant difference suggesting an improved pelvic posture wherein left sided asymmetry was reduced by 2.12° (4.24 mm). Postural corrections were generally found to be the best after the third phase. We explained these findings by an increased emphasis on the accuracy of exercise technique and in the individual findings of muscle imbalance. Some exercises in the exercise set are technically demanding. Their incorrect or incomplete performance – in the event of muscular imbalance – could negatively affect the muscle coordination in the region of the shoulder girdle and cause variations in the symmetry of shoulder posture. Pelvic posture also responded in the context of effects of movement chains. Positive trends towards the subjective perception of an improved stance stability were observed.

During the evaluation of angles that characterize the spinal curvature, we found a significant change in the angle of cervical lordosis, namely an increase by 10.27°, after the phase 1 intervention exercise. Concerning the angles characterizing the thoracic and lumbar spine, we found a factual increase by 1.43° in thoracic kyphosis and decrease in the depth of lumbar lordosis by 2.31°. No significant correlations were found between the change in the spinal curvature and range of titubation. In the second phase, only a factual increase in the angle values were found for lordoses, namely by 7.79° (cervical lordosis) and 1.55° (lumbar lordosis), while the mean angle of thoracic kyphosis responded by a suggested trend towards correction of kyphotic posture by 0.90°. In the third phase, we reported a positive change for cervical lordosis and thoracic kyphosis (2.21° and 0.22°, respectively), while a suggested deepening by 1.05° was found for lumbar lordosis. These differences were not statistically significant (TABLE 4).

As we already mentioned, these women evaluated the subjective feeling of improved stance stability very positively. A detailed case analysis of the results of the individual probands revealed that the postural system responded on an individual basis according to its setting and observance of the exercise techniques. Therefore changes in the response of the axial system to the chosen intervention manifested both as positive corrections and also zero changes.

Previous analysis provides a certain response to the thoughts of Vařeková et al. (2007), who raised the question as to whether a high frequency of muscular shortening and weakening is the norm in older age. Known anatomical principles pertaining to "ageing" of the muscular apparatus require a regular, target oriented musculoskeletal activity, which shall become a basis for further positively tuned structural and physiological settings. The entire age spectrum of our society should be educated in terms of primary care and healthy movement.

CONCLUSIONS

The study groups of women of a young senior age had their mean body weight and height within the range of normal values for the Czech population. BMI and analysis of body composition indicated a more robust constitution and slight overweight.

When evaluating the changes in the average spinal curvature in the frontal plane after the completion of the exercise program in the years 2005, 2006, and 2007, a shift of the axial system was found towards the zero vertical axis and primarily a reduction in the mean range of titubations. This condition manifested by a subjective feeling of improved stance stability.

With respect to the shoulder posture, a fluctuation was found, namely a shift in the shoulder asymmetry. Pelvis posture also responded to the interventional exercise by shifting the asymmetry of spinal angles, and after the 3rd phase, a significant compensation of the left sided asymmetry.

When evaluating the angles characterizing the spinal curvature, we reported variability of the response in the sense of a factual increase or decrease in the depth of lordoses. The best results were achieved after the 3rd phase of research, when increased emphasis was placed on proper technique of performance of individual exercises. Their improper or incomplete performance – in the event of muscular imbalance – could negatively affect the muscle coordination in the region of the shoulder and pelvic girdles. When asked for subjective evaluation, women emphasized improved stance stability.

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ANALÝZA POSTURY POLOHOVÝM SNÍMAČEM DTP2 U ŽEN VE VĚKU SENESCENCE PO APLIKACI CÍLENÉHO CVIČEBNÍHO PROGRAMU

(Souhrn anglického textu)

U 3 souborů žen v mladším seniorském věku (průměrný věk 61, 63 a 66 let) jsme v roce 2005, 2006 a 2007 sledovali změny v držení těla a ve tvaru páteře pomocí diagnostického přístroje DTP2 po intervenčním zásahu cíleného cvičebního programu (čínské terapeutické cvičení Chuej čchun kung). Cvičení ovlivnilo především oblast pánve, trendy naznačující zlepšení držení těla a stability nedosáhly ve všech případech statistické významnosti. Vzhledem k tomu, že technika cvičení je cíleně náročná, nesprávně provedené pozice nevedly ke zlepšení, ale projevily se nulovým efektem.

Vždy byly nalezeny pozitivní změny ve smyslu zlepšení stability stoje a signifikantního posunu hrudní kyfózy k vertikále, což svědčí o zlepšení držení těla. V postavení ramen se projevila určitá rozkolísanost ve smyslu změn asymetrie ramen. Také postavení pánve reagovalo na intervenční zásahy přesuny asymetrie spinálních úhlů po 1. a 2. etapě cvičení, po 3. etapě došlo ke statisticky významnému vyrovnání levostranné asymetrie. Nalezli jsme zmenšení rozsahu titubací axiálního skeletu, což je doprovodným projevem zvýšení stability stoje. Celkově se nejlepší výsledky projevily po intervenci v roce 2007, kdy se snížil rozsah titubací ve směru osy x i y, byla zjištěna statisticky významná pozitivní změna v úpravě symetrie spina iliaca posterior superior a nalezen věcně významný trend snížení úhlových hodnot lordóz i hrudní kyfózy. Zdůvodnění těchto změn je možné najít ve

zvýšeném důrazu na správné provádění technik cvičení a tím i úprav svalových dysbalancí.

Subjektivní pocity seniorek byly velmi příznivé, vysoce pozitivně hodnotily pocit zlepšení stability stoje.

Klíčová slova: držení těla, DTP2, ženy, senescence, cílený cvičební program.

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