EFECTUL ACTIVITĂŢILOR FIZICE PRACTICATE ÎN SĂLI DE FITNESS ASUPRA POSTURII FEMEILOR ADULTE

EFFECTS OF PHYSICAL ACTIVITY PRACTICED IN GYMS ON ADULT WOMEN'S POSTURE

Kalman Klara[16], Hanţiu Iacob[17]

Key words: body posture, physical deficiencies, adult women, physical activity

Abstract

Aim: The purpose of our study was to evaluate the effects of physical activity practiced in gyms on body posture, body attitude and detection of visible physical deficiencies, postural disorders of adult women.

Subjects and methods: The study involved 95 adult women from Oradea, practiotioners of physical exercises in a fitness center. Period of the study: February 2015 - June 2016. For the posture assessment, the global and segmental somatoscopic exams (and photo images) were performed. The physical activity program consisted of Step - aerobics, Pilates and strength training in the gym, 3 times a week for 60-90 minutes each session, for 12 months. The data obtained were statistically analyzed with the SPSS program.

Results: In the initial global somatoscopic assessment, it was found that 48,4% of the subjects had scoliotic body attitudes, 18,9% lordotic, 13,7% normal body attitude, 6,3% kypho-lordotic, 5,3% kyphotic and lordotic-scoliotic and 1,1% military attitude and kypho-lordo-scoliotic. After participating in the training, the final global somatoscopic assessment shows that 40% of the subjects had scoliotic attitude, 17,9% lordotic, 33,7% normal body attitude, 2,1% kypho-lordotic, 2,1% kyphotic, 3,2% lordo-scoliotic, and 1,1% kypho-lordo-scoliotic.

Conclusions: Applying the physical activity program for 12 months contributed to improvements in global body attitude and posture, the number of people with a normal global postural attitude rising from 13 to 32. In segmental somatoscopic assessment, improvements can be seen in all body segments.

Cuvinte cheie: atitudine corporală, postura, deficienţe fizice, femei adulte, activitate fizică

Rezumat

Scop: Scopul studiului nostru a fost evaluarea efectului activităţilor fizice practicate în săli de fitness asupra atitudinii corporale globale şi depistarea deficienţelor fizice vizibile la femei adulte.

Subiecţi şi metode: La acest studiu au participat 95 de femei adulte din Oradea, practicante ale exerciţiilor fizice într-o sală de fitness. Perioada studiului: februarie 2015 – iunie 2016. Pentru evaluarea posturii s-a efectuat examenul somatoscopic global şi segmentar (şi prin imagini foto). Programul de activitate fizică a constat din antrenamente combinate de Step – aerobic, Pilates şi antrenament de forţă, 3 şedinţe pe săptămâna a 60-90 de minute fiecare şedinţă, timp de 12 luni. Datele obţinute au fost analizate statistic cu programul SPSS.

Rezultate: La evaluarea somatoscopică globală iniţială s-a constatat că 48,4% dintre subiecţi au avut atitudine corporală scoliotică, 18,9% lordotică, 13,7% atitudine corporală normală, 6,3% cifo-lordotică, câte 5,3% cifotică şi lordo-scoliotică şi câte 1,1% atitudine plan-rigidă şi cifo-lordo-scoliotică. După participare la antrenamente, evaluarea somatoscopică globală finală arată că 40% dintre subiecţi au avut atitudine corporală scoliotică, 17,9% lordotică, 33,7% atitudine corporală normală, 2,1% cifo-lordotică, 2,1% cifotică, 3,2% lordo-scoliotică şi 1,1% cifo-lordo-scoliotică.

Concluzii: Aplicarea programului de activitate fizică timp de 12 luni a contribuit la îmbunătăţiri ale atitudinii corporale globale şi ale posturii, numărul persoanelor cu atitudine posturală globală normală crescând de la 13 persoane la 32. La evaluarea somatoscopică segmentară se pot observa îmbunătăţiri la toate segmentele corpului.

[16] PhD student, Babeş-Bolyai University, Cluj-Napoca, România;
Corresponding author: nagy.klara89@yahoo.com
[17] Prof.PhD, Babeş-Bolyai University, Cluj-Napoca, România

Background

The study of the attitude of the human body has been concerned and continues to concern researchers in different fields, due to the complexity of the issues associated with this concept. Being talking about human, the notion of harmonious development includes, besides the physical component, also the psychic one [1].

According to Rosário [2] the study of human posture is relatively new compared to other areas of medical science. Posture can be altered by certain phychological conditions [3,4]. However, it is not an easy subject to study, mainly because postural assessments are still scientifically inaccurate [4]. Two methods are widely used for such assessments: the study of the projection of the center of gravity with the aid of a force platform; and photography of the standing posture, using both frontal and sagittal planes [4]. Some methods, such as MRI, are expensive, while others, such as X-ray, involve radiation problems [5,6,7].

The explanatory dictionary of the Romanian language in 2009 defines the attitude that:

- ✓ Attire, posture or position of the body
- ✓ How to behave towards an event or aspect of reality [8].

Bratu in 1997 defines body attitude as follows:

„ ... the spatial projection of the body into the most frequently used positions and actions of man in his everyday affairs, but especially in standing, sitting, lying, as well as walking. The attitude of the body is the result of the interaction of several factors, including: the hereditary predispositions manifested by the constitutional type, the type of superior nervous activity, the tonicity of the muscles, the character of the professional and the habitual skills, the individual preoccupations for its formation and maintenance."[9].

Body attitude is a "position of the body and its segments present both in static and during movements, provided by cortical and subcortical motor centers, based on proprioceptive, vestibular, visual and auditory complex information. Body activities contribute to forming a correct attitude" [10].

Due to the fact that the term "attitude" has several meanings, in the literature it tends to be replaced by the term "posture".

Attaining a posture we need:

- passive elements (bones, joints etc),
- active elements (neuro-muscular system).

Deviations from the normality of posture are called physical deficiencies. They are characterized by pathological changes and are primarily produced in the shape and structure of the body and are manifested by slowing growth or by excessive growth, by non-harmonious or disproportionate development, through deviations, deformations or other morphological defects. Deficiencies may be: global or partial; somatic, organic or psychic; light, medium or accentuated [11].

Aim: The purpose of our study was to evaluate the effects of physical activity practiced in gyms on global body posture, body attitude and detection of visible physical deficiencies of adult women.

Hypothesis: Physical activity programs practiced in gyms can have a beneficial effect on global body attitude by improving or correcting it.

Materials and methods

Subjects

This study involved 95 adult women (originally 119), who attended two gyms of Fit4U Fitness Center in Oradea.

Period of the study: February 2015 - June 2016. Baseline assessment were conducted in February-March 2015. The subjects attended the gym for 12 months, and during May-June 2016 were carried out the follow-up evaluations. At the follow-up evaluation participated 95 women of 119, others abandoned/quitted along the way (for various reasons: maternity leave, over 2 weeks of physical inactivity).

The research included only those women who showed interest, accepted the measurements and gave permission that their data to be used in research. So it was non-random sampling, from non probabilistic sample category we used the convenience [12].

Methods

The global and segmental somatoscopic examination was performed.

The segmental somatoscopic examination was performed from the anterior, posterior and lateral view.

We have been following the next issues:

- head and neck position:
  - if they are on the same vertical as the trunk;
  - if there are anterior or lateral inclinations.
- Position of shoulders and upper limbs:
  - the lateral or posterior shoulder inclinations are noted;
- Spine position: the appearance of the curves in all planes
- The position of the hip: if it is laterally tilted, in anteversion/retroversion.
- Lower limb positions: the possibility of varum/valgum knee; plantar vault.

For the storage, objectification and confirmation of the data of the global and segmental somatoscopic examination, the assessment was carried out also by photo images at the posture grid wall, under the same conditions.

The photos obtained in this way were processed on the computer as follows:

- the 3 pictures taken from the 3 views were mounted together;
- a vertical line was drawn in the longitudinal axis;
- it was highlighted what was found in the visual somatoscopic examination (Figure no. 1).

The data obtained were statistically analyzed with the SPSS program (descriptive analysis, frequency).

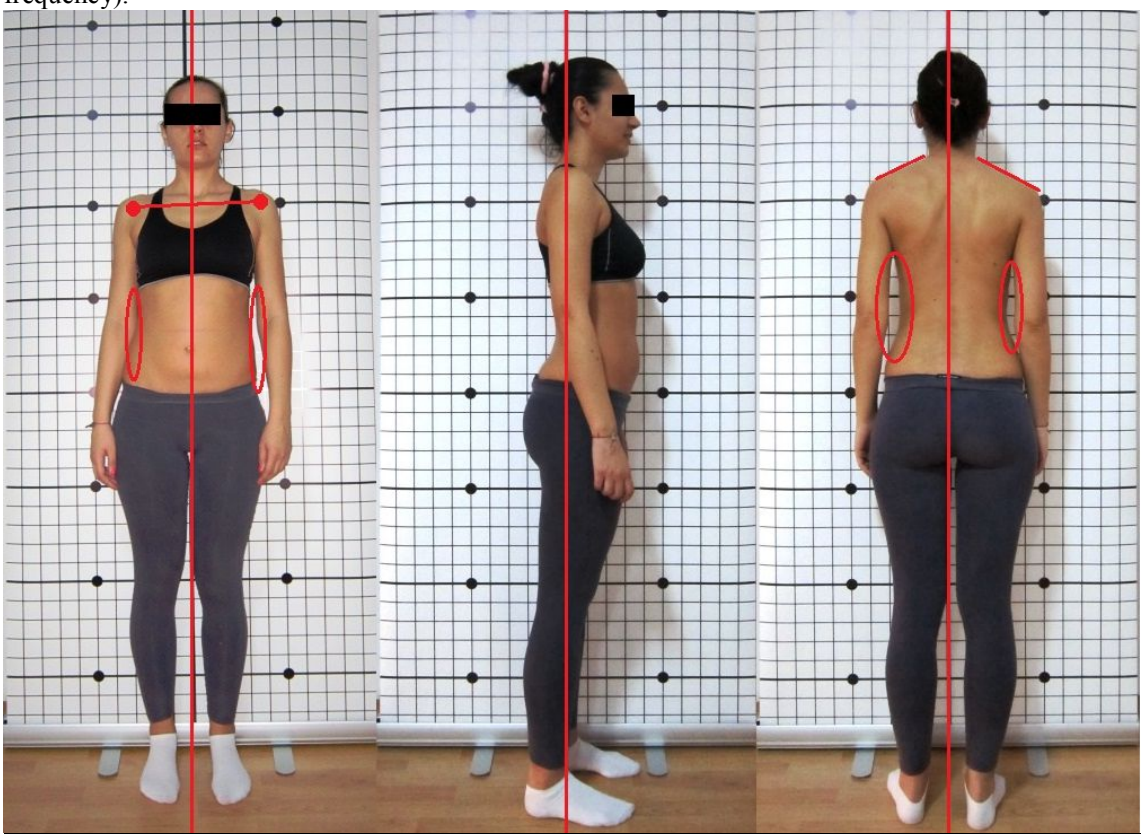

Figure no. 1: Somatoscopic exam by photos

Physical activity program

The physical activity program consisted in combined training of Step - aerobics, Pilates and strength training in the gym, 3 times a week for 60-90 minutes each session, for 12 months.

Depending on individual objectives (correcting the type of attitude) was different the type of the exercises used.

To correct body postures the following types of exercises were used: postural reeducation, stretching, stress relieving of shortened muscles, for increasing range of motion, for the "core" muscles (Pilates).

Muscle strenghtening was conducted mainly in the following muscle groups: transversus abdominis, oblique abdominals, rectus abdominis, paravertebral muscles, pelvic floor muscles, glutes, lower limb and upper limb muscles.

Results

They were assessed 95 adult women, aged between 18 and 52 years. Subjects distribution by age categories are shown in Table no. 1.

Table no.1. Subjects distribution by age categories

	18–24 years	25-34 years	35–44 years	45–54 years	Total 18-54 years
No. of subjects	41	31	14	9	95
Percentage	43,2%	32,6%	14,7%	9,5%	100%

The descriptive analysis of the demographic data of the subjects can be seen in Table no.2.

Table nr. 2. Descriptive analysis of the demographic data of the subjects (N=95)

Demographic data	Assessment	Descriptive analysis		
		Media (±AS)	Min	Max
Age (years)		28,45 (±8,74)	18	52
Height (cm)		166,88 (±6,36)	150	190
Weight (kg)	Baseline	63,67 (±11,69)	43	103
	Follow-up	62,39 (±10,63)	43	98
BMI	Baseline	22,86 (±3,76)	16,61	36,49
	Follow-up	22,40 (±3,60)	16,96	34,72

Were evaluated 95 adult women, of whom at the initial global somatoscopic assessment 46 (48.4%) had a scoliotic body attitude, 18 (18,9%) lordotic, 13 (13,7%) normal body attitude, 6 (6,3%) kypho-lordotic, 5 – 5 (5,3%) kyphotic and lordo-scoliotic and 1 – 1 (1,1%) military attitude and kypho-lordo-scoliotic (Table no.3).

After participating in the training, the final global somatoscopic assessment shows that 38 (40%) of the subjects had scoliotic attitude, 17 (17,9%) lordotic, 32 (33,7%) normal body attitude, 2 (2,1%) kypho-lordotic, 2 (2,1%) kyphotic, 3 (3,2%) lordo-scoliotic, and 1 (1,1%) kypho-lordo-scoliotic (Table no.3).

Table no.3. Prevalence of global postural attitudes at baseline and follow-up assessment (N=95)

GLOBALE POSTURAL ATTITUDE	BASELINE		FOLLOW-UP	
	No. of subjects	Percentage	No. of subjects	Percentage
Normal	13	13,7%	32	33,7%
Lordotic	18	18,9%	17	17,9%
Kyphotic	5	5,3%	2	2,1%
Scoliotic	46	48,4%	38	40%
Kypho-lordotic	6	6,3%	2	2,1%
Lordo-scoliotic	5	5,3%	3	3,2%

Kypho-lordo-scoliotic	1	1,1%	1	1,1%
Military	1	1,1%	-	-
TOTAL	**95**	**100%**	**95**	**100%**

In segmental somatoscopic assessment, before and after the intervention program, head and neck position, shoulder, spine, pelvis and lower limbs were analyzed. We found the following:

1. Head and neck position - initial assessment: 37,9% had a normal position, 48,4% forward head position, 8,4% of the subjects showed the left or right head inclined, 3,2% the head bent forward, 2,1% left or right twisted head. At the final evaluation, 65,3% had a normal head and neck position, 31,6% forward head, and 1,1% inclined head, head bent forward, respectively twisted (Table no. 4).

Table no.4. Head and neck segmental somatoscopic assessment, baseline and follow-up

Head and neck position	BASELINE		FOLLOW-UP	
	No. of subjects	Percentage	No. of subjects	Percentage
Normal	36	37,9%	62	65,3%
Forward head	46	48,4%	30	31,6%
Inclined left/right	8	8,4%	1	1,1%
Bent forward	3	3,2%	1	1,1%
Twisted left/right	2	2,1%	1	1,1%
TOTAL	**95**	**100%**	**95**	**100%**

2. Shoulder position - initial assessment: 23,2% had a normal position, 73,7% had a shoulder higher or lower than the other, 2,1% had rounded shoulders, and 1,1% had a shoulder higher and forward at the same time. At the final evaluation, 51,6% had a symmetrical shoulder position, 46,3% had a shoulder higher or lower than the other, 1,1% had rounded shoulders, respectively a shoulder higher and forward (Table no.5).

Table no.5. Baseline and follow-up segmental somatoscopic assessment of the shoulders

Shoulder position	BASELINE		FOLLOW-UP	
	No. of subjects	Percentage	No. of subjects	Percentage
Normal	22	23,2%	49	51,6%
Higher/lower	70	73,7%	44	46,3%
Rounded	2	2,1%	1	1,1%
Higher and forward	1	1,1%	1	1,1%
TOTAL	**95**	**100%**	**95**	**100%**

3. Vertebral column - initial assessment: 7,4% had no deviation or minor deflection of the spine, 43,2% had a form of scoliosis (in C, S, lumbar, thoracic, dorso-lumbar etc.), 22,1% had lordo-scoliosis, 14,7% lumbar hyperlordosis, 6,3% kypho-lordo-scoliosis, 2,1% kyphosis, respectively military (flat) back with scoliosis and 1,1% kypho-lordosis, respectively kypho-scoliosis. At the final evaluation, 24,2% showed no deflection or minor deflection of the spine, 41,1% had scoliosis, 16,8% lumbar hyperlordosis, 11,6% lordo-scoliosis, 4,2% kypho-lordo-scoliosis, 1,1% kypho-lordosis, respectively kypho-scoliosis (Table no. 6). We have not found any subjects with kyphosis or military (flat) back.

Table no.6.: Baseline and follow-up segmental somatoscopic assessment of the spine

Vertebral column	BASELINE		FOLLOW-UP	
	No. of subjects	Percentage	No. of subjects	Percentage
No/minor deviation	7	7,4%	23	24,2%
Scoliosis	41	43,2%	39	41,1%
Lordo-scoliosis	21	22,1%	11	11,6%
Lumbar hyperlordosis	14	14,7%	16	16,8%

Kypho-lordo-scoliosis	6	6,3%	4	4,2%
Kyphosis	2	2,1%	-	-
Flat back + scoliosis	2	2,1%	-	-
Kypho-lordosis	1	1,1%	1	1,1%
Kypho-scoliosis	1	1,1%	1	1,1%
TOTAL	**95**	**100%**	**95**	**100%**

4. Position of the hip - initial assessment: 32,6% had a normal position, 33,7% had hip anteversion, 14,7% had translated the hip left or right, 13,7% had a combination of anteversion and translation, 3,2% had a lateral tilt of the hip, and 1,1% showed lateral tilt with translation, respectively tilted anteversion. At the final assessment, 48,4% had a normal position, 29,5% had anteversion, 11,6% had translated the hip left or right, 7,4% had a combination of anteversion and translation, and 3,2% had a lateral tilt (Table no.7).

Table no.7.: Baseline and follow-up segmental somatoscopic assessment of the hip

Position of the hip	**BASELINE**		**FOLLOW-UP**	
	No. of subjects	**Percentage**	**No. of subjects**	**Percentage**
Normal	31	32,6%	46	48,4%
Anteversion	32	33,7%	28	29,5%
Translation left/right	14	14,7%	11	11,6%
Anteversion + translation	13	13,7%	7	7,4%
Tilted	3	3,2%	3	3,2%
Translation + tilted	1	1,1%	-	-
Tilted + anteversion	1	1,1%	-	-
TOTAL	**95**	**100%**	**95**	**100%**

5. Lower limbs position - initial assessment: 62,1% had no deviations, 23,2% had genu valgum, 5.3% valgum genu with flat foot, 4,2% had external rotation at one or both legs, 3,2% had a flat foot, 2,1% genus varum. At the final assessment, 78,9% had no deviations at the lower limbs, 14,7% had genu valgum, 3,2% flat foot and 1,1% genu varum, external rotation and genu valg with flat foot (Table no. 8).

Table nr.8.: Baseline and follow-up segmenatal somatoscopic assessment of the lower limbs

Poziţia membrelor inferioare	**BASELINE**		**FOLLOW-UP**	
	No. of subjects	**Percentage**	**No. of subjects**	**Percentage**
Normal	59	62,1%	75	78,9%
Genu valgum	22	23,2%	14	14,7%
Genu varum	2	2,1%	1	1,1%
Flat foot	3	3,2%	3	3,2%
External rotation	4	4,2%	1	1,1%
Genu valgum + flat foot	6	5,3%	1	1,1%
TOTAL	**95**	**100%**	**95**	**100%**

Discussions

At the baseline assessment of global postural attitude only 13,7% of the subjects had a normal posture, in contrast at the final assessment this percentage increased to 33,7%. A study conducted in 2011 by Ferreira and collaborators, with a similar number of subjects (115), in which posture was assessed by anterior, posterior and lateral view of photographs, shows that there is no symmetry in postural alignment and that small asymmetries represent the normative standard for posture in orthostatism [13].

According to McEvoy and Grimmer [14], the literature does not notice a standard approach to evaluate posture. The methodologies used in the study of postural alignments differ [15], and research usually evaluates only one segment, such as head and shoulder position [16,17,18], curvature and length

of thoracic kyphosis and lumbar lordosis [19,20] or the alignment of the spine and pelvis in the lateral view [21], hampering any comparison of the results.

The main tool used to assess posture is visual analysis [22], which can be aided by photos.

In our study, the most frequent postural defficency attitude was scoliotic (48,4% at baseline and 40% at final assessment).

Bogdani et al. [23] in a study analyzing recent literature on the effects of physical activity on posture and postural control, concluded that: in general, there are few studies focusing on the effects of physical activity on postural control and adjustments and also all the studies have enrolled a low number of subject which lead to a necessity for further research with larger groups of subjects and different type of physical activity intervention programs in order to better identify which is the most effective.

At segmental somatoscopic assessment the most common postural disorders were:

- forward head (48,4% at baseline assessment). In the literature, we find similar results: Griegel-Morris et al. [24] found, evaluating a group of 88 healthy volunteers (41 men and 47 women), that 66% of the subjects had the forward head position;
- one shoulder higher or lower than the other (73,7% at baseline assessment); Raine and Twomey [16] pointed out that the right shoulder had a 1° alignment lower than the left shoulder (on 160 asymptomatic subjects, 88 women and 72 males); Ferreira and co-workers [13] confirm the foundings by Raine and Twomey: the right shoulder was lower than the left shoulder, indicating a right tilt in 68% of the sample (115 subjects: 86 women, 29 men);
- scoliosis at the spine (43,2% baseline assessment);
- anteversion of the hip (33,7% baseline assessment);
- genu valgus at lower limbs (23,2% baseline assessment). Numerous studies reflect the valgus alignment of the lower limbs, especially in women [25,26,27].

Conclusions

Applying physical activity programs for 12 months contributed to improvements in global body attitude and improvements in body posture, the number of people with a normal global postural attitude rising from 13 to 32. Also, in segmental somatoscopic assessment, improvements can be seen in all segments of the body. So we can conclude that the hypothesis has been confirmed: physical activity programs have a beneficial effect on global body attitude by improving or correcting it.

Following the study, there were cases of major physical deficiencies, some were unaware of the severity of the deficiencies. They have been referred to a specialist and physiotherapist.

References

[1]. Marcu V, Baştiurea E, Zenovia Stan, Chiuculiţă C. (2008). *Determinarea dezechilibrelor musculare prezente la nivelul trunchiului*. Galaţi: Editura Academica.

[2]. Rosário JLP. (2014) Photographic analysis of human posture: A literature review. *Journal of Bodywork and Movement Therapies*, Volume 18, Issue 1, 56 - 61

[3]. James H, Castaneda L, Miller ME, Findley T. (2009) Rolfing structural integration treatment of cervical spine dysfunction. *J. Bodywork Move. Ther.* 13 (3), 229-238.

[4]. Rosário JLP., Nakashima IY, Rizopoulos K, Kostopoulos D, Marques AP (2012) Improving posture: comparing segmental stretch and muscular chains therapy. *Clin. Chiropractic*. Volume 15, Issues 3–4, December 2012, Pages 121-128

[5]. Suzuki H, Endo K, Mizuochi J, Kobayashi H, Tanaka H, Yamamoto K (2010) Clasped position for measurement of sagittal spinal alignment. *Eur. Spine J.* 19, 782-786.

[6]. Berthonnaud E, Dimnet J, Hilmi R (2009) Classification of pelvic and spinal postural patterns in upright position. Specific cases of scoliotic patients. *Comput. Med. Imaging Graphics* 33(8), 634-643.

[7]. Steffen JS, Obeid I, Aurouer N, Hauger O, Vital JM, Dubousset J, Skalli W (2010) 3D postural balance with regard to gravity line: an evaluation in the transversal plane on 93 patients and 23 asymptomatic volunteers. *Eur. Spine J.* 19, 760-767.

[8]. Academia Română, Institutul de Lingvistică „Iorgu Iordan". (2009). *Dicţionarul explicativ al limbii române (ediţia a II-a revăzută şi adăugită)*. Editura Univers Enciclopedic Gold

[9]. Bratu I, (1977) – *Gimnastica pentru prevenirea şi corectarea deficienţelor fizice*, Editura Sport-Turism, Bucureşti

[10]. Nicu A (coord). (2002). *Enciclopedia educaţiei fizice şi sportului în România*. Editura Aramis, Bucureşti
[11]. Şerbescu Carmen (2011) Kinetoterapia deficienţelor fizice – note de curs
[12]. Şandor SD (2013) *Metode şi tehnici de cercetare în ştiinţele sociale*. Bucureşti: Tritonic.
[13]. Ferreira EA, Duarte M, Maldonado EP, Bersanetti AA, Marques AP (2011) Quantitative assessment of postural alignment in young adults based on photographs of anterior, posterior, and lateral views. *Journal of Manipulative and Physiological Therapeutics*, http://dx.doi.org/10.1016/j.jmpt.2011.05.018
[14]. McEvoy MP, Grimmer K (2005) Reliability of upright posture measurements in primary school children. *BMC MusculoskeletDisord* 2005;29:6-35.
[15]. Normand MC, Descarreaux M, Harrrison DD, Harrison DE, Perron DL, Ferrantelli JR, Janik TJ (2007) Three dimensional evaluation of posture in standing with the PosturePrint: anintra-and inter-examiner reliability study. *Chiropr Osteopat* 2007;15:15-26.
[16]. Raine S, Twomey LT (1997) Head and shoulder posture variations in 160 asymptomatic women and men. *Arch Phys Med Rehabil* 1997;78:1215-23.
[17]. Aitken A (2008) *Reliability of visual assessment of forward head posture in standing*. Master of Osteopathy, Unitec.
[18]. Carneiro Paula Rossi, Cardoso Bárbara dos Santos, Cunha Caroline Modesto da, & Teles Lídia Cristina da Silva. (2014). Reliability intra-and inter-examiner of the head postural assessment by computerized photogrammetry. *Fisioterapia e Pesquisa*, *21*(1), 34-39. https://dx.doi.org/10.1590/1809-2950/402210114
[19]. Leroux MA, Zabjek K, Simard G, Badeaux J, Coillard C, Rivard CH (2000) A noninvasive anthropometric technique for measuring kyphosis and lordosis: an application for idiopathic scoliosis. *Spine* 25:1689-94.
[20]. Dunleavy K, Mariano H, Wiater T, Goldberg A. (2010) Reliability and minimal detectable change of spinal length and width measurements using the Flexicurve for usual standing posture in healthy young adults. *J Back Musculoskelet Rehabil* 23:209-14.
[21]. Roussouly P, Gollogly S, Berthonnaud E, Dimnet J (2005) Classification of the normal variation in the sagittal alignment of the human lumbar spine and pelvis in the standing position. *Spine* 30:346-53.
[22]. Gangnet N, Pomero V, Dumas R, Skalli W, Vital JM (2003) Variability of the spine and pelvis location with respect to the gravity line: a three-dimensional stereoradiographic study using a force platform. *Surg Radiol Anat*. 25(5-6):424-33
[23]. Bogdani A, Pano G (2016) Physical activity effects on postural adjustments: a review. *Journal of Human Sports and Exercise*. 11. . 10.14198/jhse.2016.11.Proc1.15.
[24]. Griegel-Morris P, Larson K, Mueller-Klaus K, Oatis CA (1992) Incidence of common postural abnormalities in the cervical, shoulder, and thoracic regions and their association with pain in two age groups of healthy subjects. *Phys Ther* 1992; 72:425-31.
[25]. Hsu RW, Himeno S, Coventry MB, Chao EY (1990) Normal axial alignment of the lower extremity and load-bearing distribution at the knee. *Clin Orthop Relat Res*. 1990:215-227.
[26]. Cahuzac JP, Vardon D, Sales de Gauzy J (1995) Development of the clinical tibiofemoral angle in normal adolescents. A study of 427 normal subjects from 10 to 16 years of age. *J Bone Joint Surg Br*.1995; 77:729-732.
[27]. Nguyen AD, Shultz SJ (2007) Sex differences in clinical measures of lower extremity alignment. *J Orthop Sports Phys Ther* 2007; 37:389-98.