

Changes of the body posture in the sagittal plane of young adults during Matthiass test

Magdalena Zawadka (✉ magdalenazawadka91@gmail.com)

Medical University of Lublin <https://orcid.org/0000-0001-6087-017X>

Maciej Kochman

Uniwersytet Medyczny w Lublinie

Piotr Gawda

Uniwersytet Medyczny w Lublinie

Mirosław Jablonski

Uniwersytet Medyczny w Lublinie

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Abstract

Background Postural assessment is an important part of the physical examination in the physical therapy practice. One of the most commonly used clinical tests is an arm-raising Matthiass test. The aim of this study was to investigate posture changes in sagittal plane observed during Matthiass test in young adults using a rasterstereography method.

Methods Fourteen young and healthy volunteers, nine female and four male aged between 21 and 25 took part in this study. Examination s performed with the rasterstereographic measuring device.

Results Trunk inclination significantly decreased during Matthiass test and the pelvis inclination increased. Distance between kyphosis apex and cervical lordosis apex was significantly shorter during the test than in standing position. Distance between kyphosis apex and lumbar lordosis apex significantly increased during Matthiass test. Kyphosis angle was significantly decreased and the lumbar lordosis angle was increased during the test.

Conclusion The results of this study suggest that Matthias test can cause significant deviations in posture in young participants. Changes in the sagittal plane are observed mainly right after the elevation of the arms.

Introduction

Body posture can be described as the orientation of body segments relative to the gravitational vector[1]. Posture deformities can be a serious problem in developing countries due to a sedentary lifestyle. Posture examination is an important part of the physical examination in physical therapy practice. One of the most widely used clinical tests is arm-raising Matthiass test. It evaluates the dynamic postural performance in the sagittal plane during standing with arms lifted forward to 90° shoulder flexion for 30 s. The Matthiass posture test is dedicated to detecting posture changes in children and adolescents [2]. It is a fast and safe detection method of posture weaknesses. However, visual assessment is subjective. That is why it can lead to inconsistent conclusions.

Radiography seems to be an unsuitable method for screening postural deformity in early stages. Moreover, it is risky when used for repeated monitoring because of invasive character. Therefore, various examination methods enabling non-invasive posture assessment have been developed [3, 4]. Rasterstereography is one of the radiation-free methods used to analyze the three-dimensional back shape. It has been shown as an

accurate tool used for examination postural changes in scoliosis [5-7], Scheuermann disease [8], and leg length inequality [9, 10]. Previously demonstrated good reliability of rasterstereographic measurements shows their validity and reliability during static measures, such as the Matthiass test [2]. However, it is not clear what kind of postural changes in the sagittal plane are observed in Matthias test after the adolescence in young adulthood.

The aim of this study was to investigate posture changes in the sagittal plane observed during Matthias test in young adults using the rasterstereography method.

Methods

Study design

Fourteen young volunteers, nine female and four male aged between 21 and 25 (mean \pm SD: aged 22.14 ± 1.12 years), took part in this study. Participants were healthy, free of any injury or pain for at least a month prior to testing and did not have diagnosed scoliosis or Scheuermann disease. Subjects gave their written informed consent to participate in this examination. Table 1. shows the weight, height and Body Mass Index of the participants.

Examination was performed with the rasterstereographic measuring system Formetric 4D (Diers International GmbH, Schlangenbad, Germany). Parallel white light lines are projected on the back surface of the participant by the slide projector. The 3-dimensional back shape leads to a deformation of the parallel light lines, which can be detected by the camera. Anatomic landmarks are thereby automatically captured by assigning concave and convex areas to curved light pattern during 6 s [11]. Based on the automatic detection of the dorsal process of the seventh vertebral body (VP) and of the right and left lumbar dimple (DR and DL), the software was able to calculate the number of parameters. In this study 6 parameters were analyzed: Trunk inclination [deg], Pelvis inclination [deg], Distance between kyphosis apex and cervical lordosis apex (K-CL) [mm], Distance between

kyphosis apex and lumbar lordosis apex (K-LL) [mm], Kyphosis angle [deg], Lumbar lordosis angle [deg].

Position of the pelvis can be drawn because the lumbar dimples are in close relation to the underlying posterior superior iliac spines of the pelvis. Positive pelvis inclination means forward tilt and negative values mean backward tilt of the pelvis. Trunk inclination was calculated as the distance in the sagittal plane between the VP and the middle point between lumbar dimples. A positive value was interpreted as an increase in inclination in an anterior direction [12, 13]. Kyphosis angle was calculated between inflectional point cervicothoracic and inflectional point thoracolumbar, lumbar lordosis angle was calculated between inflectional point thoracolumbar and inflectional point lumbosacral. Rasterstereographic method previously occurred as a reliable tool for examination of healthy volunteers posture in the sagittal plane [14, 15].

According to previous studies, participants were instructed to stand with their feet shoulder-width apart, looking straight ahead [16]. First measure of spinal curvature and pelvic tilt was made during normal standing position in 6s period time. When asked, subjects flexed their arms to 90°. Spinal curvature and pelvic tilt were measured again (Matthiass 1, 0s+6 s). Participants were instructed to retain this posture for 30 seconds, after which time a third spinal curvature and pelvic tilt measurement was made (Matthiass 2, 30 s+6 s). After the third measure, participants were asked to lower down their arms. The program DIERS formetric 4D average (static trial, 2 frames/s, averaging 12 frames during 6s) was used for data collection and processing.

Statistical analysis

Statistical analysis was carried out using Statistica 13.1 analytics software. Shapiro-Wilk test revealed that the data were not normally distributed. Non-parametric tests were used for further statistical analysis. Three pairs of measurements (Matthiass1 vs Matthiass2; Matthiass1 vs standing position; Matthiass 2 vs standing position) were compared using Wilcoxon matched pairs test. Spearman rang correlation was calculated for all parameters during 3 measurements. Statistical significance was accepted at $p < 0.05$ with all outcome measures reported as median and ranges (minimum and maximum).

Results

Trunk inclination significantly decreased during Matthiass test from 2.40 to -2.10 deg. Pelvis inclination was increased in Matthias 2 comparing to a normal standing position (21.71 and 22.70 deg respectively). K-CL was significantly smaller in Matthias 1 and Matthias 2 than in standing position (28.52, 24.97 and 51.59 mm respectively). K-LL significantly increased during Matthiass test from 35.02 mm (in normal standing position) to 59.07 mm (in Matthias 2). Kyphosis angle was significantly smaller in Matthias 1 than in normal standing position (33.10 and 43.82 deg respectively). Lumbar lordosis angle was slightly larger in Matthias 1 and Matthias 2 than in normal standing position (39.09, 39.29 and 38.55 deg respectively). There were significant changes between Matthias 1 and Matthias 2 only in trunk inclination and K-LL. Table 1 shows the median and ranges of parameters and Table 2 shows statistic results and p-values.

Table 1 Median, minimum and maximum of parameters.

Parameters	Median	Minimum	Maximum
Mass [kg]	65.00	50.00	83.00
Height [cm]	172.00	157.00	182.00
BMI (Body Mass Index)[kg/m ²]	22.61	18.71	25.06
Normal standing position			
Trunk inclination [deg]	2.40	-0.77	5.71
Pelvis inclination [deg]	21.71	7.65	37.80
K-CL [mm]	51.59	25.60	72.81
K-LL [mm]	35.02	18.19	45.58
Kyphosis angle [deg]	43.82	27.58	58.33
Lumbar lordosis angle [deg]	38.55	21.52	63.90
Matthiass 1			
Trunk inclination [deg]	-0.77	-4.79	3.98
Pelvis inclination [deg]	21.02	4.80	35.23
K-CL [mm]	28.52	0.00	65.78
K-LL [mm]	50.94	28.73	70.71
Kyphosis angle [deg]	33.10	15.10	51.40
Lumbar lordosis angle [deg]	39.09	23.67	81.72
Matthiass 2			
Trunk inclination [deg]	-2.10	-5.64	0.85
Pelvis inclination [deg]	22.70	2.69	35.71
K-CL [mm]	24.97	0.00	61.75
K-LL [mm]	59.07	39.41	69.72
Kyphosis angle [deg]	39.38	19.68	52.08
Lumbar lordosis angle [deg]	39.29	27.75	66.15

Matthias1-measurment during first 6 sec of test (0s-6s). Matthiass 2-mesurments after 30 sec of test (30s -36s)

Table 2 Comparison between Matthiass test and normal standing position. Values in bold are statistically significant ($p < 0.05$).

Parameters	Matthiass1 vs Matthiass2		Matthiass1 vs standing position		Matthiass2 vs standing position	
	Z	p	Z	p	Z	p
Trunk inclination	2.73	0.006	3.11	0.002	3.30	0.001
Pelvis inclination	0.97	0.33	1.85	0.06	2.10	0.04
K-CL	1.01	0.31	3.30	0.001	3.30	0.001
K-LL	2.48	0.01	3.30	0.001	3.30	0.001
Kyphosis angle	0.78	0.43	2.42	0.02	1.98	0.05
Lordosis angle	0.03	0.97	2.73	0.006	2.86	0.004

Matthias1-measurment during first 6 sec of test (0s-6s). Mattiass 2-mesurments after 30 sec of test (30s -36s) Trunk inclination and K-LL shows moderate ($r = -0.64$) to strong ($r = -0.82$) negative correlation. Pelvis inclination is moderate positively correlated with lumbar lordosis in all three measures. K-CL shows moderate positive correlation to kyphosis angle and moderate negative correlation to lumbar lordosis angle in a normal standing position and Matthiass 2. K-LL is moderately positively correlated with lumbar lordosis angle in standing position and Matthiass 1. Matrix of correlation is presented in Table 3. Figure 1 shows changes of K-CL and K-LL during backward trunk lean.

Table 3 Spearman rank correlation matrix (Spearman's rho). Values in bold are statistically significant ($p < 0.05$).

Parameters	Trunk inclination	Pelvis inclination	K-CL	K-LL	Kyphosis angle	Lordosis angle
Normal standing position						
Trunk inclination	-	-0.17	0.38	-0.64	-0.22	-0.30
Pelvis inclination	-0.17	-	-0.61	0.33	-0.42	0.76
K-CL	0.38	-0.61	-	-0.18	0.59	-0.60
K-LL	-0.64	0.33	-0.18	-	0.45	0.69
Kyphosis angle	-0.22	-0.42	0.59	0.45	-	-0.14
Lordosis angle	-0.30	0.76	-0.60	0.69	-0.14	-
Matthiass 1						
Trunk inclination	-	-0.24	0.24	-0.82	-0.53	-0.49
Pelvis inclination	-0.24	-	-0.50	0.40	0.18	0.79
K-CL	0.24	-0.50	-	-0.37	0.30	-0.51
K-LL	-0.82	0.40	-0.37	-	0.29	0.73
Kyphosis angle	-0.53	0.18	0.30	0.29	-	0.22
Lordosis angle	-0.49	0.79	-0.51	0.73	0.22	-
Matthiass 2						
Trunk inclination	-	0.07	0.47	-0.64	0.29	-0.40
Pelvis inclination	0.07	-	-0.49	0.12	-0.27	0.68
K-CL	0.47	-0.49	-	-0.45	0.65	-0.59
K-LL	-0.64	0.11	-0.45	-	-0.41	0.43
Kyphosis angle	0.29	-0.27	0.65	-0.41	-	-0.06
Lordosis angle	-0.40	0.68	-0.59	0.43	-0.06	-

Discussion

Most studies in the field of posture evaluation have focused only on the school children or adolescents and too little attention has been paid to early adulthood. Thus, the aim of this study was to analyze posture changes in sagittal plane observed during Matthiass test in young adults using the rasterstereography method.

In this study, we investigated the trunk inclination changes from the positive value (trunk forward) to negative (trunk backward). Betsch et al. investigated healthy adolescents in modified Matthiass test with additional weight held in hands. They noticed an increase of the trunk inclination from -4.7deg to 1.3deg [12]. Our findings are in agreement with Albertsen et. al. who noticed that in healthy children (10-14 years) backward lean of the trunk and lumbar lordosis increased [17]. Pelvic inclination has not been investigated previously during posture tests.

In this study kyphosis and lordosis angles in the normal standing position were 43.82 and 38.55 degrees respectively. Furian et al. in their study investigated school children and noted greater values of these parameters. Mean kyphosis value was 47.1(7.5) and mean lordosis was 42.1 (9.9) [13]. However, Betsch et al. show that in starting position lordosis and kyphosis angles in adolescents were about 30 degrees [12].

We have noticed a small but statistically significant increase in lumbar lordosis, which is consistent with previous studies [12, 17] Kyphosis angle in our study significantly decreased when arms were lifted. Significant reduction of the kyphosis angle caused by elevating limbs was previously reported by Betsch et al. [12]. but not by Albertsen et al. [17] who reported an increase of kyphosis angle. Lifting the arms leads to a relocation of the center of gravity, what can be compensated by trunk backward lean and altered muscles activation of back extensors stabilizing spine posture. Thus, involved changes can decrease thoracic kyphosis. K-CLL and K-LL have not been investigated so far, but we believe they bring some new light to posture changes involved by Matthiass test and can be useful for describing human posture. Greater K-LL correlated with trunk inclination and lumbar lordosis angle indicate that posture is shifted backward by the increase of pelvic inclination and lumbar lordosis. Decreased of K-CL during Matthiass test is related to kyphosis decrease and lordosis increase. Interestingly, lumbar lordosis and thoracic kyphosis seem to be independent and show no correlation to each other. Widhe reported that the correlation coefficient between lordosis and kyphosis was significant only in boys and young girls, but not in adolescent girls aged 15-16 [18]. In our study nine of 14 participants

are females. Further investigation in the group of young adults with a comparison of female and male can give firm conclusions.

It is interesting that postural changes are involved immediately after arms lifting. During a period of 30 s, only trunk inclination decreased and K-LL increased significantly without significant changes of other parameters. Probably the posture mechanism is related to the ankle joint strategy for saving balance [1]. The main limitation of this study was a small sample size. This investigation needs to be repeated in a larger number of participants to confirm our results.

Conclusions

The results of this study suggest that Matthias test can cause significant deviations in posture in young participants. Changes in sagittal plane are observed right after the elevation of the arms. After the 30 s only trunk backward lean significantly increased. This finding provides further support for the hypothesis that Matthias test leads to a significant reduction of the kyphosis angle and increased lumbar lordosis.

Declarations

Availability of data and materials

All data used and analysed during the current study are available from the corresponding author on reasonable request.

List of abbreviations

SD: standard deviation

VP: dorsal process of the seventh vertebral body

DR and DL: right and left lumbar dimple

K-CL: Distance between kyphosis apex and cervical lordosis apex

K-LL: Distance between kyphosis apex and lumbar lordosis apex

BMI: Body Mass Index

r: Spearman's rho

Z: Wilcoxon matched pairs test

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Authors' Contributions

MZ, MK, PG, MJ - study design

MZ, MK-data collection

All authors have read and approved the final manuscript.

Ethics declarations

Ethics approval and consent to participate

The ethics committee of the Medical University of Lublin (KE-0254/258/2018) approved the procedures of the study and experiments were carried out according to the Declaration of Helsinki. Written informed consent was obtained from all participants.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

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Figures

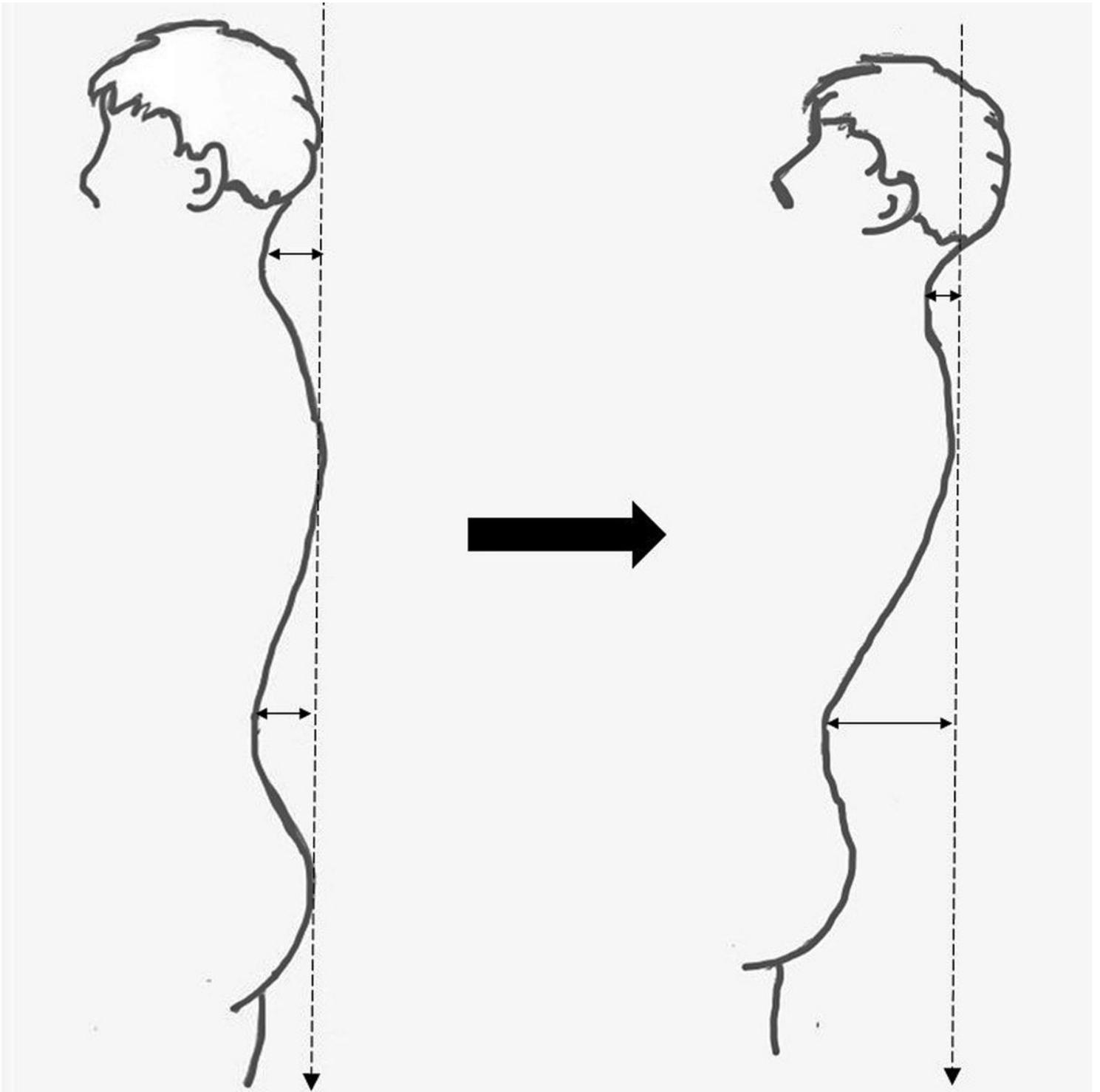


Figure 1

Changes of distance between kyphosis apex and lumbar lordosis apex/cervical lordosis apex during backward trunk lean in Matthiass test.