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Maintaining body posture in the modified Matthias test depending on sex and the physical activity level in the population of young people — preliminary research

ABSTRACT

Background: Low physical activity observed in young people may cause changes in body posture, which adversely affects the osteoarticular system of the spine. The light-optical scanning method based on Video Raster-Stereography (VRS) allows the objectification of the modified Matthias test (mMT) in dynamic conditions. This study aims to assess the ability to maintain body posture in the mMT depending on sex and physical activity level in the young population.

Materials and methods: The study was conducted in a group of 24 people (10 men, 14 women) aged 19–25. The subjects were divided into a group of men and women where energy expenditure was recorded and the parameters of the mMT were measured.

Results: In the mMT, there is a statistical significance in the trunk inclination angle (TI) (from the vertical, mMT) — first measurement ($p = 0.050$); kyphosis angle (KA) (mMT) — first measurement ($p = 0.037$); KA (mMT) — second measurement ($p = 0.050$). Sex is a differentiating factor for those variables where women scored higher.

Conclusions: The analysed significance of differences in the examined parameters may be related to the biomechanical, musculoskeletal, and physiological characteristics of men and women, which affects the muscle strength needed to maintain a static forced body posture.

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KEY WORDS: body posture; energy expenditure; modified Matthias test

INTRODUCTION

The low level of physical activity observed in young people may cause changes in body posture, which has an adverse effect on the osteoarticular system of the spine. The promotion of physical activity among university students is beneficial not only for the physical health and well-being of students, but also for mental health and well-being and academic performance. Despite the known benefits, physical activity levels (PALs) in this age group often tend to decrease. The majority of university students do not meet the guidelines for adequate levels of physical activity, so promoting physical activity among these students is needed [1].

Many hours of static postures while using various electronic devices such as computers, tablets and mobile phones cause unfavourable changes in the sagittal curvatures of the spine. Head protraction predominantly occurs, resulting in excessive postural muscle tension, which increases static loads on the spinal joints [2].

Non-invasive, without harmful radiation, three-dimensional postural analysis is

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a combination of optical technology and digital data processing. It is also used to analyse the three-dimensional (extrapolated) shape of the spine in patients with idiopathic scoliosis. Some studies proved its value for assessing spinal shape and its high reliability in assessing trunk shape, especially in static tests in children and healthy subjects [3].

The light-optical scanning method based on Video Raster-Stereography (VRS) allows the assessment of the modified Matthias test (mMT) for the evaluation of the sagittal plane, performed under dynamic conditions, to be objectified. The additional load held in the subject's hands (test modification), of only 5% of their body weight, causes significant postural changes during the test, even in healthy subjects. The use of the mMT and the dynamic use of a surface topography system allows a quick, objective, and safe assessment of the postural changes that occur during the MT [4].

To date, there is a lack of information in the literature on the changes occurring in the sagittal plane during different forms of physical activity and the „normative" values of the shape of the sagittal plane of the spine in people with different levels of daily physical activity (DPA).

This study aims to evaluate the ability to maintain posture in the mMT, which assesses the spine in the sagittal plane, in a group of young adults taking into account sex distribution and level of DPA.

The results obtained are to be used, in a group of young adults, in the development of diagnostic and therapeutic programmes and in the prevention of overload lesions of the spine.

MATERIAL AND METHODS

The study was conducted in a group of 24 subjects (10 men, 14 women) aged 19–25 years, students at the Medical University of Silesia. The subjects were in good health to perform various forms of endurance exercise (healthy subjects — without cardiovascular diseases, without significant disorders of the respiratory system, nervous system, and musculoskeletal system, and in the absence of other diseases). Students who did not agree to participate in the study were not eligible. Non-cooperators were excluded from the study. The study was conducted in accordance with the Declaration of Helsinki and was approved by the Bioethics Committee of the Medical University of Silesia in Katowice, no. KNW/0022/KB1/56/I/19. All subjects underwent assessment of energy expenditure using the ActiGraphGT3X accelerometer. The observation time was 7 days. On this basis, the mean energy expenditure and the number of steps taken were obtained. The subjects were divided into two groups: Group I — women (14 subjects), Group II — men (10 subjects) (Table 1). The next stage of the study was to measure the sagittal curvatures of the spine using a gravity goniometer (Rippstein V plurimeter) and perform a three-dimensional (3D) optical spine analysis using the DIERS machine. The mMT using the DIERS device assessed the sagittal curvatures of the trunk/spine under isometric tension of the back muscles. During the measurements, the participants were in an upright position, standing with their backs to the system, feet hip-width apart. The heels were aligned in a line to normalise the foot position, the gaze was focused on a point at eye level. Participants performed three trials. During the first static measurement, the arms were positioned along the trunk (static test). During the second measurement in the Matthias test (mMT), students kept their upper limbs extended horizontally in front of them for 30 seconds so as to maintain 90° flexion at the shoulder joint (first dynamic trial). In the third measurement lasting 30 seconds — same position as before — participants held an additional weight of 5% of the subject's body weight in their hands — second dynamic trial [3]. The trunk inclination angle (TI) was measured, which is between the vertical and the line connecting the end of the spinous process of the seventh cervical vertebra to the midpoint located between the posterior superior iliac spines (PSISs) [4]. The maximum kyphosis angle (KA) and maximum lordosis angle (LA) were also measured in the surface topography image. The measurement of KA, on the mMT using Diers technology, represents the angle contained between the passing tangents of the cervicothoracic and thoracolumbar segments. The LA is measured between the passing tangents of the thoracolumbar and lumbosacral segments [5]. Statistical calculations were performed using Statistica Statsoft 13.0 for the assumed significance level of $\alpha = 0.05$. During preliminary data analysis, using the Shapiro-Wilk test, the distribution was found to be non-normal for the following variables: TI (from the vertical, mMT) — first measurement (women: $W = 0.87297$, $p = 0.04619$); TI (from the vertical, mMT) — second measurement (women: W = 0.86526, p = 0.03602); lordosis (measurement using a Plurimeter-V gravity inclinometer) (women: W = 0.85496, p = 0.02596; men: W = 0.77773, p = 0.00777); LA (mMT) — first measurement (women: W = 0.85419, p = **,02533**; men: W = 0.84061, p = 0.04488); LA (mMT) — second measurement (women: W = 0.81263, p = 0.00718). For the remaining variables, the distribution was found to be normal. The non-parametric Mann-Whitney U test or the parametric Student's t-test for independent variables were used to verify the hypothesis of differences between the male and female groups. For nominal variables, the Pearson test was used and the V-Cramer's coefficient was calculated.

RESULTS

The difference in the values of thoracic kyphosis and lumbar lordosis measured with the Rippstein Plurimeter-V gravity inclinometer in the groups of men and women studied was not statistically significant. In Group I — women, the value of kyphosis was 35.9° ± 7.08 and the value of lordosis was 30.8° ± 5.99. In Group II — men, the value of kyphosis was 30.8° ± 6.0 and the value of lordosis was 30.9° ± 5.7 (Tab. 1). These values demonstrate the homogeneity of both groups in terms of spinal curvatures. Sex of the subjects is also not a differentiating factor when comparing energy expenditure measured over 7 days (p = 0.41). Half (50%) of the subjects (in the study group) with low energy expenditure were found to be women. In the group with high energy expenditure, women represented 66.67% (Tab. 2).

In the mMT, statistically significant differences were found in the values of TI (from the vertical, mMT) — first measurement (p = 0.050); KA (mMT) — first measurement (p = 0.037); KA (mMT) — second measurement (p = 0.050). Sex is a differentiating factor for these variables where women obtained higher values (Table 3). No significant statistical relationship was found for the following variables: TI (from the vertical, mMT) — second measurement (p = 0.169); TI (from the vertical, mMT) — third measurement (p = 0.225); kyphosis (p = 0.080); lordosis (p = 1.000); LA (mMT) — first measurement (p = 0.349); LA (mMT) — second measurement (p = 0.128); KA (mMT) — third measurement (p = 0.199); LA (mMT) — third measurement (p = 0.271). In summary, men and women obtained similar levels of values in these tests (Tab. 3).

DISCUSSION

The MT assesses the ability of muscles to maintain posture. In effect, the strength and endurance of the abdominal and back muscles are tested. The test allows a quantitative and qualitative assessment of the action of the muscular forces balancing the body weight. Under physiological conditions, when

Table 1. Characteristics of study groups, level of energy expenditure

	Group I — women (n = 14)					Group II — men (n = 10)				
	Mean	SD	Median	Min.	Max.	Mean	SD	Median	Min.	Max.
Total Activity [kcal]	2626.2	1021.62	2239.1	1578	4609	3375.4	1349.42	3332	1201	5431
Body weight [kg]	62.0	11.68	62	44	90	84.4	13.11	84.5	65	104
Age [years]	21	0	21	21	21	21.7	0.95	21	21	23
Body height [cm]	167.0	6.91	166	156	178	180.5	6.06	182.5	170	188
BMI	22.0	3.32	21.1	17.2	28.4	25.8	2.90	25.7	22.5	30.5
Weartime (%)	69.6	13.7	71.9	40.2	93.9	57.8	20.60	58.7	26.3	92.5
Total number of steps	58321.6	12897.98	59665	39017	82259	49600.2	13865.32	49248.5	20097	66607
Kyphosis [°] Plurimeter	35.9	7.08	37.5	21	50	30.8	6.00	30	20	40
Lordosis [°] Plurimeter	30.8	5.99	30	20	42	30.9	5.70	30	20	40

SD — standard deviation; BMI — body mass index

Table 2. Energy expenditure compared to sex of the subjects

	Low energy expenditure		High energy expenditure		Statistical analysis		
	n	%	n	%		p	V
Women	6	50	8	67%	0.69	0.41	0.17
Men	6	50	4	33%			

Pearson test

Table 3. Sex of the subjects compared to the modified Matthias test (mMT)

Parameters mMT [°]	Group I — women (n = 14)					Group II — men (n = 10)					Statistical analysis
	Mean	SD	Median	Min.	Max.	Mean	SD	Median	Min.	Max.	p
TI 1**	5.43	2.79	6	1	9	2.80	2.86	2	0	9	0.050
TI 2**	8.64	3.86	8	4	14	6.40	3.27	6.5	3	13	0.169
TI 3*	10.29	5.01	10	2	22	7.90	3.96	7.5	1	14	0.225
KA 1*	59.71	7.26	58.5	49	72	53.00	7.32	55	39	62	0.037
KA 2*	50.86	7.39	50	39	68	41.80	14.37	37.5	15	63	0.050
KA 3*	50.79	18.44	47	23	86	41.60	13.99	41.5	22	63	0.199
LA 1**	49.00	12.50	45.5	34	79	44.40	8.91	42.5	35	66	0.349
LA 2**	52.57	11.69	49.5	42	82	44.90	6.95	46	35	56	0.128
LA 3*	51.50	8.40	51.5	40	68	47.40	9.26	47.5	33	69	0.271

*Student's t-test for independent variables; **Mann-Whitney U-test; SD — standard deviation; TI 1 — trunk inclination angle (first position, arms along the trunk); TI 2 — trunk inclination angle (second position, arms raised); TI 3 — trunk inclination angle (second position, arms raised with load); KA 1 — kyphosis angle (first position, arms along the trunk); KA 2 — kyphosis angle (second position, arms raised); KA 3 — kyphosis angle (second position, arms raised with load); LA 1 — lordosis angle (first position, arms along the trunk); LA 2 — lordosis angle (second position, arms raised); LA 3 — lordosis angle (second position, arms raised with load)

the arms are raised, the subject leans the whole trunk backwards and the centre of gravity of the head moves forwards. Full muscle performance will allow the correct ability to maintain posture in a position of complete uprightness or slight posterior displacement of the trunk position. When the postural muscles are weakened, there will be an increase in the curvatures of the spine — thoracic kyphosis and lumbar lordosis [6, 7]. In the mMT, there is a significant reduction in KA due to limb elevation as described by Betsch et al. [4]. The study was performed in a group of 31 athletes with an average age of 14 years. In another study conducted in a group of 101 healthy children, the mMT causes an increase in KA. These differences may be due to the level of postural performance, which may be helpful in identifying posturally weak children [3]. To date, the mMT has not differentiated postural performance according to energy expenditure and sex. In the results obtained, there was a significant difference in the parameters of TI (from the vertical, mMT) — first measurement, and KA (mMT) — first and second measurement. In the first measurement, in the standing position, the arms were positioned along the trunk. In the second measurement, the arms were raised to a 90º angle without holding additional weight. Larger significant values were recorded in women. The added extra weight in the third measurement did not affect the significant difference between the study groups in terms of TI, KA, and LA parameters. The significantly higher values in the first measurement of TI (from the vertical, mMT) and in the first and second measurement of KA (mMT) may be due to different body proportions, skeletal structure, muscular development, and location of body fat. These sex differences in biomechanical, musculoskeletal, and physiological characteristics affect muscle strength. For the major muscles or muscle groups in the human body, men's muscle strength is greater on average than women's.

Women are more flexible in terms of joint range of motion for complex movements. The average range of motion of the body in many joints such as the elbow, shoulder and hip joints is greater in women than in men [8-10]. The lack of significant differences in the third measurement where participants held an extra weight in their raised arms may be due to similar energy expenditure recorded. Energy expenditure depends on the PAL. In most publications, men's activity levels are higher than women's [11]. Raising the arms leads to a displacement of the centre of gravity, which can be compensated for by a backward-leaning trunk and altered activation of the back extensor muscles stabilising the posture of the spine. Maintaining a static position causes significant postural discomfort which is the result of overlapping biomechanical and physiological stresses [12]. The inclination angle of the shoulder in weight-bearing significantly affects postural discomfort in both male and female groups. The observed effect of shoulder angle is associated with an increase in intramuscular pressure and reduced blood flow in the upper limb muscles [13]. Postural discomfort experienced during physical work is one of the main concepts of physical ergonomics and work biomechanics. Numerous studies linked postural discomfort to an increased risk of work-related musculoskeletal disorders [14].

The study has its limitations in terms of the short time taken to record energy expenditure and the small number of participants.

CONCLUSIONS

The analysed significance of differences in the studied parameters may be related to biomechanical, musculoskeletal, and physiological characteristics of men and women, which has an impact on the muscular strength needed to maintain a static forced body posture.

The results of the study imply that further research (on a larger group of individuals) into the assessment of postural muscle performance in terms of sex differences and energy expenditure during daily activity is needed, and this may contribute to the development of methods for the prevention of overload lesions in young people.

DATA AVAILABILITY STATEMENT

Data confirming the results of this study are available in the article

ETHICS STATEMENT

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Bioethics Committee of the Medical University of Silesia in Katowice No. KNW/0022/KB1/56/I/19.

AUTHOR CONTRIBUTIONS

All the authors have made significant contributions to the concept, data acquisition, analysis, and interpretation. Bartosz Wnuk wrote the article and other authors approved it for publication.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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