ORIGINAL ARTICLE

Effects of a 90-minute wrestling training on the selected features of the shape of spine and pelvis under load

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

Alicja Kaiser[1ABCDE], Marek Sokołowski[2ABCD], Mirosław Mrozkowiak[3ABCD]

[1] Department of Didactics of Tourism and Recreation, Poznań School of Banking, Poland
[2] Department of the Methodology of Physical Education, University School of Physical Education in Poznań, Poland
[3] Department of Physical Education, Kazimierz Wielki University in Bydgoszcz, Poland

Source of support: Departmental sources

Received: 17 October 2013; **Accepted:** 31 January 2014; **Published online:** 13 March 2014

ICID: 1094026

Abstract

Background & Study Aim: The ability to transfer vertical load is conditioned, among others, by the symmetry of the spine in the frontal plane and by the optimal values of angles of physiological curvatures in the sagittal plane. The repeatability and intensity of exercise in modern competitive sports require a great deal of "resilience" of the skeletal system, each discipline having a substantial, specific impact on the load-bearing functions of the skeleton. Sports training can result in the development of disorders associated with excessive load, especially concerning young organisms. The aim of the present study is the impact of the 90-minute wrestling workout on some selected features of the shape of the spine and pelvis under the conditions of increased load for reasons of health of young female wrestlers.

Material & Methods: The examinations were carried out in February 2012 among 30 female wrestlers from the Polish National Wrestling Team (mean ± SD, age: 16,8±1,21 years; body height: 163±5,77 cm; body mass: 54,1±9,28 kg). The method was based on assessing angle values and lengths of the spine in three planes, and on evaluating the pelvis in the frontal and transverse planes. The examination was carried out before and after a specialist training. Evaluation of the selected spinal features was carried out using a test stand for computer analysis of body posture (Posturometer M).

Results: High and medium statistically significant changes occurred among the examined population of female wrestlers as an effect of axial load on the sagittal plane. Insignificant changes were found in the frontal and transverse planes. Very significant changes were observed in the inclination angle in the lumbosacral region (Alpha), the total of partial angles (Delta), the total length of the spine (DCK), the length (DKP), height (RKP) and depth (GKP) of thoracic kyphosis as well as the angle (KLL) and height (RLL) of lumbar lordosis.

Conclusions: Training regimes in base training for female wrestlers should incorporate correction of deficits in ranges of motion in hip and shoulder joints, strength endurance of hip extensor muscles and the muscles of upper thoracic part of body trunk. Wrestling training for female wrestlers should focus more on preventing back pain and stimulating a general endurance of the body.

Autor's address: Alicja Kaiser, Department of Didactics of Tourism and Recreation, Poznań School of Banking, Al. Niepodległości 2, 61-874, Poznań, Poland, e-mail: alicja_kaiser@poczta.fm

Key words: habitual posture · health · kyphosis · lordosis · projection moiré

Introduction

The ability to transfer vertical load is conditioned, among others, by the symmetry of the spine in the frontal plane and by the optimal values of angles of physiological curvatures in the sagittal plane. The disturbed function of the pelvis in the sagittal plane might lead to changes in angular values of physiological curvatures, whereas disturbances in a frontal or transverse plane result in an asymmetrical profile of the line of spinous processes. A proper muscle tone is essential for a correct body posture and motor activity. It should be sufficient to prevent the effect

Habitual posture – determined by the tension of tonic and phasic muscles maintaining the body in an upright position, with limbs hanging loosely in an optimal, individual position, keeping a static and dynamic balance.

Spine – an adult's body is on average 70-75 cm long, which constitutes 40-45% of body height, and it consists of c. 33 vertebrae with alternating physiological sagittal curvatures. The spine provides support for the body sections located above the base of the sacrum.

Kyphosis – sagittal physiological front-to-back curve of thoracic spine.

Lordosis – sagittal physiological back-to-front curve of lumbar spine.

Projection moiré – a term derived from the name of a French fabric called "moiré", on which one can observe the appearance of light and dark fringe patterns. This is the result of an interference of two geometrical systems of linear structures (gratings-rasters). Interference effect is shown in the formation of a new system of lines (straight-line gratings) – moiré patterns. Moiré line gratings similarly to contour lines on the map describe the actual shape of an object.

Health – is defined in the Constitution of the World Health Organisation of 1948 as a state of complete physical, social and mental well-being, and not merely the absence of disease or infirmity.

of gravitational forces and low enough to allow for smooth selective movements or isolated activity [1]. The efficiency of the system of body posture control depends on the internal and external determinants, such as fatigue, emotional states, body temperature, atmospheric pressure and other factors [2].

Modern training regimes in professional sports involve doing repeated strenuous exercises that require enormous endurance of the skeletal system, especially the spine. The majority of sports disciplines affect human vertebral column [3-7]. For example, tennis is a frequent cause of abnormalities in the lower lumbar spine at L 4/5 and L 5/S1 levels; lumbar pars injuries and facet joint arthroses are relatively common diseases among tennis players [8]. The examination of young sumo wrestlers showed a significant correlation between spondylolysis and lumbar symptoms which indicates that young sumo wrestlers give up to continue this sport because of symptomatic spondylolysis [9]. Cervical spine abnormalities consisting of degenerative discopathy are observed in professional male rugby players aged > 21 years, as shown in the study carried out among French rugby union clubs between 2002 and 2006 [10]. The spine is even more exposed to injury in sports involving additional load, e.g. an opponent or partner (wrestling, judo, figure skating) or several partners (human pyramids in acrobatic gymnastics), or in disciplines which require sports equipment (weightlifting or hammer throw) [11]. High control of body posture is crucial in acrobatics, air racing, track and field or combat sports. The results of the studies examining effects of disturbances on the performance of the system of body posture control are useful when working with athletes and caring for their health.

The aim of the present study is the impact of the 90-minute wrestling workout on some selected features of the shape of the spine and pelvis under the conditions of increased load for reasons of health of young female wrestlers.

Material and methods

Characteristics of the Research Sample

The research study was carried out in The Wrestling Training Centre in Poznań, Poland, during a sports camp. Physical examinations involved 30 female representatives of the Polish National Wrestling Team, aged 15 to 20 years, which accounts for 86% of the national team members in this age category. The average body mass in the examined group amounted to 54 kg, with an average height of 163 cm and average training experience of 5 years (see Table 1).

The wrestlers were in their transition period that began after the last wrestling competition, the transition period included two mesocycles: a period of active rest and the period of preparation for training. The first mesocycle included various forms of exercises, which were different in nature from a professional wrestling fight, they were often in the form of play and were characterized by a low intensity of physical effort. In order to heal and prevent injuries biological regeneration treatment was introduced, which involved recreational activities at the swimming pool as well as carrying out periodic medical examinations. At the end of the mesocycle the wrestlers were prepared physically and mentally for the next wrestling season. In preparation for the training the wrestlers participated in an increased number of sports activities, the so-called practical subjects, such as team games and overall general fitness activities. At the end of their transition period the female wrestlers took part in the specialized wrestling training. This study was carried out in the last days of training. Parental and guardian consent had been obtained before testing team members under 18. The authors were given informed consent and approval by Ethics Committee to carry out their research.

Procedure

In order to achieve their research aims, the authors strove to find the most reliable and comprehensive perspective on the axially loaded body posture in wrestlers. The study was carried out using the innovative apparatus for computer assessment of posture by projection moiré system. Projection moiré technique is a new, noninvasive method of spatial photogrammetry. It involves the use of an optical raster that refracts a beam of light. As a result, the image thus obtained is received by a special optical system which transmits it onto the computer screen. The advantages of this method are a high rate of registration, the simultaneity of measurement(s) and a high accuracy of results [12-16]. For the first time the analysis included a tensometric mat and a posturometer, which allowed to select the most frequent and recurrent occurrences of lower-limb loading. The most essential feature of this method is simultaneous measurement of all actual values of spatial location in individual body sections. The method consisted in measuring 29 selected features that describe body posture in the sagittal, frontal and transverse planes in the area of pelvis and physiological spinal curvatures, the measurements were conducted twice – before and after training (Table 2).

The examinations were carried out before and after a 90-minute specialized training, with axial load

Table 1. Sample group - 30 female representatives of the Polish National Wrestling Team

No.	Date of Birth (age)	Body Mass [kg]	Body Height [cm]	Age Category*	Weight class*	Training Experience [years]
1	1996 (15)	39	153	Youngster	5 (40kg)	5
2	1996 (15)	44	155	Youngster	6 (44kg)	4
3	1996 (15)	54	165	Youngster	9 (57kg)	4
4	1996 (15)	43	158	Youngster	6 (44kg)	7
5	1995 (16)	51	160	Cadet	6 (52kg)	4
6	1995 (16)	39	161	Cadet	2 (40kg)	4
7	1995 (16)	60	160	Cadet	8 (60kg)	3
8	1995 (16)	48	155	Cadet	5 (49kg)	7
9	1995 (16)	70	163	Cadet	10 (70kg)	8
10	1995 (16)	46	158	Cadet	4 (46kg)	5
11	1995 (16)	56	167	Cadet	7 (56kg)	4
12	1995 (16)	57	165	Cadet	8 (60kg)	4
13	1994 (17)	45	160	Cadet	4 (46kg)	6
14	1994 (17)	52	156	Cadet	7 (56kg)	7
15	1994 (17)	61	165	Cadet	9 (65kg)	3
16	1994 (17)	53	170	Cadet	7 (56kg)	6
17	1994 (17)	68	166	Cadet	10 (70kg)	6
18	1994 (17)	60	167	Cadet	8 (60kg)	5
19	1994 (17)	64	169	Cadet	9 (65kg))	3
20	1994 (17)	53	165	Cadet	7 (56kg	6
21	1994 (17)	67	170	Cadet	10 (70kg)	2
22	1994 (17)	40	160	Cadet	2 (40kg)	4
23	1994 (17)	67	165	Cadet	10 (70kg)	8
24	1994 (17)	49	160	Cadet	5 (49kg)	7
25	1993 (18)	72	180	Junior	8 (72kg)	6
26	1992 (19)	52	168	Junior	4 (55kg)	6
27	1993 (18)	58	158	Junior	5 (59kg)	3
28	1993 (18)	48	158	Junior	2 (48kg)	5
29	1992 (19)	52	168	Junior	4 (55kg)	6
30	1991(20)	55	165	Junior	4 (55kg)	7
Mean values (± SD)	16.8 ±1.21	54.1 ± 9.28	163 ±5.77	-	-	5.2± 1.62

* FILA – International Wrestling Regulations (Corsie-sur-Vevey (SUI) – February 2010

Source: authors' own elaboration

adjusted individually for each athlete. It was assumed that the load of 1/3 of the body mass of an athlete symmetrically located on the shoulder girdle should effectively modify the studied features of body posture. This assumption was made considering the following factors: changes in the musculoskeletal system typical of the puberty period of human life [17], transitory period of a training cycle, and the fact that the load during a wrestling fight accounts for a third of the opponent's body mass.

In order to evaluate the measured features, the authors used a test stand for computer analysis of body posture (Posturometer M). The measurement stand was composed of a computer, a card, dedicated software, a printer and projector-receiver equipment with a

Table 2. Features measured for pelvis – vertebral column system

No.	Symbol	Evaluated features		
		Unit	Name	Details
Sagittal Plane				
1	Alpha	degree	Inclination of lumbopelvic region	
2	Beta	degree	Inclination of thoracolumbar region	
3	Gamma	degree	Inclination of upper thoracic region	
4	Delta	degree	Total of angular values	Delta = Alpha + Beta + Gamma
5	DCK	mm	Total length of the spine	Distance between C7 and S1, measured in vertical axis
6	KPT	degree	Angle of extension	Defined as a deviation of C7-S1 line from vertical position (backwards)
7	KPT -	degree	Angle of body bent	Defined as a deviation of C7-S1 line from vertical position (forwards)
8	DKP	mm	thoracic kyphosis length	Distance between points C7 and PL
9	KKP	degree	Angle of thoracic kyphosis	KKP = 180 – (Beta+Gamma)
10	RKP	mm	Thoracic kyphosis height	Distance between points C7 and PL
11	GKP	mm	Thoracic kyphosis depth	Distance measured horizontally between the vertical lines passing through the points PL and KP
12	DLL	mm	Lumbar lordosis length	Distance between point KP and S1
13	KLL	degree	Angle of lumbar lordosis	KLL = 180 – (Alpha + Beta)
14	RLL	mm	Lumbar lordosis height	Distance between point PL and S1
15	GLL -	mm	Lumbar lordosis depth	Distance measured horizontally between the vertical lines passing through the points PL and LL
Frontal Plane				
16	KNT -	degree	Angle of body bent to the side	Defined as a deviation of C7 – S1 line from vertical position to the left
17	KNT	degree		Defined as a deviation of C7 – S1 line from vertical position to the right
18	LBW -	mm	Right shoulder up	Distance measured vertically between horizontal lines passing through points B2 and B4
19	LBW	mm	Left shoulder up	
20	LŁW	mm	Left scapula up	Distance measured vertically between horizontal lines passing through points Ł1 and Łp
21	LŁW -	mm	Right scapula up	
22	OL	mm	Lower angle of left scapula more distant	Difference of the distance of lower angles of scapulas from the line of spinous processes measured horizontally along the lines passing through points Łl and Łp
23	OL -	mm	Lower angle of right scapula more distant	
24	KNM	degree	Pelvis tilt, right ilium up	Angle between horizontal line and the straight line passing through the points M1 and Mp
25	KNM -	degree	Pelvis tilt, left ilium up	
26	UK	mm	Max. inclination of 1 spinous process to the right	Maximal deviation of spinous process from the line from S1. Distance measured in horizontal line.
27	UK -	mm	Max. inclination of 1 spinous process to the left	
Transverse Plane				
28	KSM	degree	Pelvis rotated to the right	Angle between the line passing through MI, perpendicular to the camera axis, and the straight line passing through MI and MP. Pelvis rotated to the right.
29	KSM -	degree	Pelvis rotated to the left	Angle between the line passing through Mp, perpendicular to the camera axis, and the straight line passing through MI and MP. Pelvis rotated to the left.

Source: authors' own elaboration

camera for measuring the selected features of the pelvis-vertebral column system. Eight anthropometric points were marked on the skin of the contestants' backs, prior to the exercise, by means of a dermatograph (lower angles of shoulders, the peak of thoracic kyphosis and lumbar lordosis, the transition of kyphosis into lordosis, spinous process of the vertebra S_1, posterior superior iliac spines), after which the 29 selected features of posture were measured. The second measurement of the same features of body posture, based on the original markings on the skin, was made immediately after the workout. Uneven distribution of body fat on the area of the back leads to difficulties in accurate assessment of posture for people whose BMI is above 25.0 – 30.0. For overweight patients, it is much harder to mark the selected anthropometric points used for the sake of calculations. In the sample group there were no such cases. Graphic spatial representation in the stand was obtained through displaying a line with specific features on the back of a subject. The lines which were displayed on the back were distorted depending on surface configuration. The use of the camera allowed for receiving the picture of a subject through an optical system and then transferring it to a computer screen. Distortions of the lines, stored in the computer memory, were processed by a numerical algorithm into contour maps of the measured surface. The picture of the surface of the back allowed for a comprehensive interpretation of body posture. Apart from the assessment of trunk asymmetry in the frontal plane, the method also allowed for the determination of spatial angular and linear features which describe pelvis, physiological curvatures and frontal asymmetry of spinous processes in the vertebral column, i.e. maximum deviation of a spinous process of a vertebra from the line C7-S1. The results obtained in the form of a spatial graphic representation allowed for a quantitative description of the measured features.

Linear values were given by the distances between selected anthropometric points on the back, whereas angular values were based on the differences in their location with respect to the height or distance from the camera. Short time of registration of subjects' profiles helped avoid exertion of postural muscles, which had been observed during examinations carried out by means of somatoscopic methods.

The results of the study were then used for statistical analysis of means, maximum and minimum standard deviations and the significance of differences in populations between classes.

Results

Mean results were divided according to the following pattern: class 1 – results obtained during the examination of the axially loaded body posture before physical exercise, class 2 – results with axial load after training (Table 3).

High and medium significant changes were found in the studied population of female wrestlers in body posture before and after training induced by axial load in the sagittal plane, whereas insignificant changes were found in the frontal and transverse planes. Very significant reduction was observed in the angle of inclination of the lumbosacral region (Alpha), in the total of partial angles (Delta), the total length of spine (DCK), the length (DKP), height (RKP) and depth (GKP) of thoracic kyphosis, and the angle (KLL) and height (RLL) of lumbar lordosis. Medium significant reduction was found in the angle of inclination of thoracolumbar region (Gamma), and in the length (DLL) and depth (GLL-) of lumbar lordosis. Furthermore, small significant reduction was observed in the angle of body bent to the right (KNT) and body trunk in the sagittal plane (KPT), the angle of shoulder line (KLB-) when the left shoulder was higher, shoulder asymmetry (LŁ) when the right shoulder was higher, pelvis tilt to the right (KNM) and in the deepening of asymmetrical profile of line of the spinous processes to the right (UK-).

Discussion

Numerous studies have demonstrated an increase in asymmetry in the frontal plane, with a particular focus on a position of the scapulae and pelvis. In an initial period, the asymmetry has a functional character and is not accompanied by structural changes in the area of passive locomotor system. With time, however, incorrect body posture becomes permanent which, in consequence, leads to scoliosis [18-20]. Training-induced body adaptations to the demands of a given sports discipline typically magnify the asymmetry [11]. Uetake and Ohtsuki [21] found progression in the angles of thoracic kyphosis and lumbar lordosis that increased with training experience. Similar tendency compared to control group was observed by Wojtys et al. [22]. Other studies have shown a statistically significant effect of long-term training on the symmetry in the frontal plane and angular values of physiological curvatures in the sagittal plane [23].

The comparison of the results obtained for the features that characterise physiological curvatures of class 1 and 2 in this study reveals that physical exercise

Table 3. Significance of differences in the studied body features in female wrestlers before and after specialised training (n=30)

No.	Symbol	Body posture								Significance of differences
		1st class				2nd class				
		min	max	$\bar{x}$	SD	Min	max	$\bar{x}$	SD	
1	Alfa	2	19	8.3	4.26	2	31	12.93	5.93	***
2	Beta	1	15	10.53	2.85	5	18	11	3.07	
3	Gamma	5	16	10	2.75	7	19	11.83	3.02	**
4	Delta	14	42	29.03	6.78	22	54	34.8	8.18	***
5	DCK	434	672	534.33	42.68	504	644	591.23	32.88	***
6	KPT	177	185	181.43	1.68	176	188	180.3	2.49	*
7	KPT-	0	0	0	0	0	0	0	0	
8	DKP	352	571	452.67	48.14	405	559	503.23	36.46	***
9	KKP	152	169	159.43	4.24	143	165	156.87	4.71	***
10	RKP	217	384	307.07	37.96	261	402	347.63	32	***
11	GKP	15	57	30.73	9.08	22	69	41.77	9.89	***
12	DLL	290	455	370.93	35.6	279	463	396.5	35.96	**
13	KLL	148	176	160.83	5.9	135	170	156.93	7.72	***
14	RLL	144	284	224.9	27.54	202	297	244.43	22.54	***
15	GLL-	7	53	32.07	10.15	16	74	37.13	13.91	**
16	KNT-	1	1	1	0	1	1	1	0	
17	KNT	0	0	2	0.39	0	1	0.12	0.34	*
18	KLB-	2	15	7.36	3.67	1	15	4.92	4.57	*
19	KLB	0	10	3.68	2.65	0	15	4.59	5.18	
20	Ł-	0	12	5.74	3.45	0	12	5.68	3.92	
21	Ł	1.7	20.5	8.71	5.71	0	35.9	10.5	8.13	*
22	OL-	0	16.1	6.28	4.45	0	98	11.23	19.64	
23	OL	0	0	0	0	0	0	0	0	
24	KNM	0	10	3.26	2.97	0	6	2.13	2.07	*
25	KNM-	0	0	0	0	0	0	0	0	
26	KSM	0	10	4	3.25	0	14	4.77	3.9	
27	KSM-	1	10	3.93	2.84	1	8	3.38	2.45	
28	UK	1	3	2	1	2	5	3.5	2.12	
29	UK-	1	7	3.67	1.78	2	9	4.68	1.89	*

Source: author's own elaboration

Legend:
*** p<0,001;** p<0,01 – 0,001; * p<0,05 – 0,01
Empty field: insignificant difference. For explanations of symbols see Tab. 2

performed by female wrestlers caused a very significant deepening of the angle of thoracic kyphosis and lumbar lordosis with a simultaneous high and medium significant increase in the partial angles (Alpha, Beta, Gamma), and in the height, length and depth of thoracic kyphosis and lumbar lordosis. Positive but small significant changes were observed in trunk verticality, asymmetry of shoulders, scapulae

and pelvis, whereas negative changes were observed in the deepening of a left-sided scoliosis. Further analyses showed that negative changes were present only in the sagittal plane; an increase in linear features of both curvatures (height, length) caused a shallower angle of thoracic kyphosis and lumbar lordosis whereas increasing the value of partial angles deepened these features. Therefore, it was an antagonist pressure. While the angle of inclination of thoracolumbar region did not show any significant changes, the modifications of other angles were very significant. This suggests the deficits in the range of motion in hip joints and shoulder joints and lower strength in the muscles that reduced anterior pelvic tilt and the tilt in the upper thoracic body region, which consequently affects the efficiency of the axial system in athletes. The possible threat is that if such dysfunctions are not treated with appropriate correction exercises, they will have a negative impact on the final results in wrestling tournaments.

The results obtained in this study are consistent with the data gathered for the population of male wrestlers from the national team, but they differ from the results obtained for judo wrestlers from the national team [24,25]. It was found that the muscular system in spine-pelvis system in judo contestants showed a lower resistance to axial load of the spine compared to muscular system of the examined wrestlers, as it deepened the angle of lumbar lordosis, the length of lumbar lordosis and thoracic kyphosis and the angle of trunk extension in the sagittal plane.

The authors' present investigation shows that in the context of a maximum body load during the competition the most important changes occur in the angular values of anterior-posterior curvatures of the spine. Such changes may reduce the efficiency of the spine-pelvis system and may, thus, contribute to a negative result of a wrestling fight. The method applied in this study allows to express spatial asymmetries of the spine in numerical values, which in turn allows for a quick modification of an applied training load in order to prevent the occurrence of possible negative changes in the region of physiological curvatures of the spine. This study assumes that the efficient functioning of anti-gravity muscles may enable good results in sport and prevent back pain and postural deformities. In supplementary training greater attention should be paid to correcting the deficits in the range of motion in the joints of the hip and shoulder, as well as to strengthening the endurance of extensor muscles of the hip and of the upper-chest area of the body.

With regard to equivocal effects of physical exercises on the body posture it has to be emphasized that the training of young wrestlers/athletes should be supervised with special attention. It is important to remember that physical training is not all about gaining success in sport, but it is also to ensure optimal health of sportspeople. The strength of muscles and physical endurance should be developed in a stable way – good health has a positive influence on the life of athletes [26,27]. Physical exercises accompanying the wrestling training, as examined in the present study, contributed to the changes in the positions of bone points and to the reduction of the tension in the chest muscles and the muscles in the lumbar part of the back. Physical effort increased tension in the thoracic section of the back, and in the abdominal muscles and the pelvic girdle; it also shallowed sagittal curvatures of the spine and reduced spinal length. Schemes aimed at preventing injuries during wrestling fight should incorporate, at the beginning and end of the training (after an appropriately long warm-up), the exercises that correct movement range deficiencies. In order to avoid muscle injuries in both abdominal and back muscle mass, our research team recommends that each training session should include, in its initial part (warm-up), a dynamic stretching in the area of all torso muscles and joints (individually and in pairs), as well as isometric and acrobatic exercises in pairs. Stretching should also be added at the end of a warm-up. The final part of the training session should include stretching exercises, a deep relaxation massage and slow jog trot. Exercises focused on correcting deficiencies in joint motion range should account for ca. ¼ of the duration of a training session. Moreover, training microcycles in combat sports should include, once a week, swimming, hydro massage, exercises of the third level of movement coordination, elongation exercises, aqua fitness and, once a week, sauna. Sauna, in all variations, is the most popular athletic recovery recommended for medical, relaxation and hygienic reasons [28-30]. The authors of the present study also suggest cryotherapy as a way of fostering athletic recovery [31].

It is worth noting that an improper wrestling training may affect in a negative way the vertebral column in young females, which might be the cause of potential medical complications during pregnancy, when additional load acts on the vertebral column and hormonal changes affect a configuration of bones and joints in the area of pelvis and the vertebral column. Therefore, trainers are advised to employ at each training session exercises that will prevent back pain or sagittal plane postural problems.

In conclusion, steps should be taken to prevent the development of body asymmetry and health related problems among professional athletes, especially in the case of young and still developing athletes. Similarly to modern physical education, tourism and recreation, awareness of health-related aspects should accompany any physical activity and sport [32-35]. An athlete's body is able to withstand maximal training loads only if the person's health status is maintained at a high level. Trainers should, therefore, take into account current recommendations of the Polish Society of Sports Medicine on age criteria for eligibility for training and competitions [36] as well as strengthen the endurance and health of young athletes through propagating a healthy lifestyle. It is essential for the sake of current and future health of athletes that elements of health-oriented training are incorporated in their training regimes. This would allow them not only to be successful in sport but also to improve their health and to form positive attitudes towards their bodies, health and physical fitness.

Conclusions

The physical exercise examined in the study caused a deepening of thoracic kyphosis and lumbar lordosis but increased the depth, height and length of physiological curvatures in the spine.

Basic training for female wrestlers should be supplemented with the correction of deficits in the range of motion in hip and shoulder joints, the strengthening of endurance of hip joint and upper (thoracic) region of body trunk.

The prevention of backache and posture deformities should constitute a regular part of the supplementary training within the basic training. The initial part of the basic training should include exercises developing the strength of postural muscles, the final part should consist of relaxation training and stretching exercises.

Acknowledgments

The Bioethics Committee of Poznań University of Medical Sciences granted permission to use their research findings in the present study within the project Characteristics of body posture in people with varied physical activity levels (sportspeople, children, teenagers, adults), according to Resolution No. 525/11.

The authors would like to thank the staff of The Wrestling Training Centre in Poznań for their kind and disinterested help with the following project. Thank you all for making your sports venue accessible for research as well as for making it possible to carry out measurements in the rooms specially adapted for this purpose. The authors also extend their gratitude to the authorities of The Polish Wrestling Federation who kindly gave their permission to carry out research during the assembly of the Polish National Wrestling Team.

Competing interests

The authors declare that they have no competing interests.

References

1. Shumway-Cook A, Woollacott M. Motor control: theory and practical applications, 2nd ed. Lippincott Williams & Wilkins Baltimore. Philadelphia; 2000
2. Perrot C, Mur J, Maynard D et al. Influence of trauma induced by judo practice on postural control. Scand J Med Sci Sports 2000; (10): 292-7
3. Lennard TA, Crabtree HM. Spine in Sports. Elsevier-Mosby. Philadelphia; 2005
4. Mroczkowski A, Jaskólski E. The change of pelvis placement at children under influence of aikido training. Arch Budo 2007; 3: 21-6
5. López-Miñarro PA, Muyor JM, Alacid F. Sagittal spinal curvatures and pelvic tilt in elite young kayakers. Med Sport 2010; 63(4): 509-19
6. Maćkowiak Z, Wiernicka M. Body posture in girls aged 13-18 involved in synchronized swimming. Polish J Sport Med 2010; 26(2-3): 115-22
7. Oliver GD, Keeley DW. Pelvis and torso kinematics and their relationship to shoulder kinematics in high-school baseball pitchers. J Strength Cond Res 2010; 24(12): 3241-46
8. Alyas F, Turner M, Connell D. MRI findings in the lumbar spines of asymptomatic, adolescent, elite tennis players. Br J Sports Med 2007; (41):836-41
9. Nakagawa Y, Mukai S, Hattori Y et al. Spondylolysis decreases sports performance in sumo wrestlers – radiological changes of lumbar spine in high school and collegiate sumo wrestlers. Br J Sports Med 2011; 45: 322
10. Castinel BH, Adam P, Milburn PD et al. Epidemiology of cervical spine abnormalities in asymptomatic adult professional rugby union players using static and dynamic MRI protocols: 2002 to 2006. Br J Sports Med 2010; 44: 194-9
11. Starosta W. Kształt kręgosłupa z punktu widzenia motoryki człowieka i motoryki sportowej. Post Rehab 1993; 7(4): 19-30 [in Polish]
12. Laulund T, Søjbjerg JO, Hørlyck E. Moiré topography in school screening for structural scoliosis. Acta Orthop Scand 1982; 53(5): 765-8
13. Uetake T, Ohtsuki F. Sagittal configuration of spinal curvature line in sportsmen using Moire technique. Okajimas Folia Anat Jpn 1993; 70(2-3): 91-103
14. Daruwalla JS, Balasubramaniam P. Moiré topography in scoliosis. Its accuracy in detecting the site and size of the curve. J Bone Joint Surg 1985; 67(2): 211-3
15. Mohsen MES. Comparison of Roentgenography and Moiré Topography for Quantifying Spinal Curvature. Phys Ther 1986; 66: 1078-1082
16. Sahlstrand T. The clinical value of moire topography in the management of scoliosis. Spine 1986; 11: 409-17
17. Stodolny J. Choroba przeciążeniowa kręgosłupa. ZL Natura. Kielce; 2004 [in Polish]
18. Nissinen M, Heliovaara M, Seitsamo J. et al. Anthropometric measurements and the incidence of low back pain in a cohort of pubertal children. Spine 1994; 19: 1367-70
19. Nissinen MJ, Heliovaara MM, Seitsamo JT et al. Development of trunk asymmetry in a cohort of children ages 11 to 22 years. Spine 2000; 25(5): 570-78
20. Poussa MS, Heliovaara MM, Seitsamo JT et al. Development of spinal posture in a cohort of children from the age of 11 to 22 years. Eur Spine J 2005; 14(8): 738-43

21. Uetake, T, Ohtsuki, F: Sagittal configuration of spinal curvature line in sportsmen using Moiré technique. Okajimas Folia Anat Jpn, 1993; 70(2-3): 91-103
22. Wojtys EM, Ashton-Miller JA, Huston LJ et al. The association between athletic training time and the sagittal curvature of the immature spine. Am J Sports Med 2000; 28(4): 490-8
23. Perrin P, Deviterne D, Hegel F et al. Judo, better than dance, develops sensorimotor adaptabilities involved in balance control. Gait Posture 2002; 15: 187-94
24. Mrozkowiak M. Analiza porównawcza krzywizn fizjologicznych kręgosłupa pod wpływem obciążenia osiowego zawodników judo i zapasów. In: Bulicz A, editor. Potęgowanie zdrowia. Czynniki, mechanizmy i strategie zdrowotne. Wyd. WSUPiZ Radom. 2003; 346-67 [in Polish]
25. Mrozkowiak M. Analiza porównawcza zespołu miednica-kręgosłup pod wpływem obciążenia osiowego w płaszczyźnie czołowej i poprzecznej zawodników judo i zapasów. In: Umiastowska D, editor. Aktywność ruchowa ludzi w różnym wieku Wyd. Promocyjne Albatros. Szczecin, 2004; 270-93 [in Polish]
26. American Academy of Pediatrics. Committee on Sports Medicine and Fitness Strength training by children and adolescents. Pediatrics 2001; 107: 1470-72
27. National Strength and Conditioning Association. Youth resistance training. Position statement paper and literature review. Strength Cond J 1996; 18: 62-75
28. Prystupa T, Wołyńska A, Ślężyński J. The Effects of Finnish Sauna on Hemodynamics of the Circulatory System in Men and Women. J Hum Kinet 2009; 22: 61-8
29. Scoon GSM, Hopkins WG, Mayhew S et al. Effect of post-exercise sauna bathing on the endurance performance of competitive male runners. J Sci Med Sport 2007; 10: 259-62
30. Sutkowy P, Woźniak A, Mila-Kierzenkowska C. Sauna – the proven and effective method of regeneration after intensive physical exercise. In: Kaiser A, Tomczak A, editors. Physical activity and health promotion in the military environment. Polish Scientific Physical Education Association Section of Physical Education in the Army. Warszawa; 2011: 173-182
31. Straburzyńska-Lupa A, Konarska A, Nowak A et al. Effect of whole-body cryotherapy on selected blood chemistry parameters in professional field hockey players, Polish Journal of Physiotherapy 2007; 7(1): 15-20
32. Mrozkowiak M, Sokołowski M, Kaiser A. Characteristics of habitual posture in female wrestlers from the Polish National Team. Med Sport 2012; 65(2): 235-51
33. Sokołowski M, Kaiser A, Czerniak U et.al: Wrestlers' health – biological, behavioral and axiological aspects. Arch Budo 2012; 8(1): 37-43
34. Boguszewski D, Świderska B, Adamczyk JG, al. Judo as a supplementary form of therapy for children with mental retardation. Arch Budo Sci Martial Art Extreme Sport 2013; 9 85-92
35. Rottermund J, Knapik A, Michał Kuszewski, et al. Biological and behavioural factors conditioning muscular power in men aged 30 to 60 years. Arch Budo Sci Martial Art Extreme Sport 2013; 9: 93-101
36. Kostka T, Furgal W, Gawroński W et.al: Recommendations of the Polish Society of Sports Medicine on age criteria while qualifying children and youths for participation in various sports. Br J Sports Med 2012; 46: 159-62.

Cite this article as: Kaiser A, Sokołowski M, Mrozkowiak M. Effects of a 90-minute wrestling training on the selected features of the shape of spine and pelvis under load. Arch Budo 2014; 10: 57-65