The Swedish Journal of Scientific Research ISSN: 2001-9211. Vol. 3. Issue 3. March. 2016

THE EFFECT OF THE DIFFERENT POSITIONS DURING TENNIS PERFORMANCE ON THE MORPHOLOGY OF THE VERTEBRAL COLUMN

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Abstract

Research objective: Studying the vertebral column morphology in the thoracic , lumbar & sacral sections as well as identifying the incidence of scoliosis in tennis players.

Research Sample: 15 players from Sultan Qaboos University tennis Team were chosen by the selective method.

Research Methodology & Material : The Spinal Mouse device was used to evaluate the vertebra using descriptive methodology.

Research Procedure: Six tests in three positions (Standing ,Flexion and Extension) were done to simulate the physical performance of the sport.Statistical evaluation suitable for the study were used :mean, standard deviation, Spermann and Person correlation factors .

Research Results: A higher mean difference in the lumbar areas in the flexion position 48.73 degrees in comparison to the thoracic and sacral area. Meanwhile a higher mean difference for the thoracic and sacral area in the extension position 26.06 & 40.73 degrees consecutively confirmed by Spermann and Person correlation factors. There was no scoliosis in the sample**.**

Research Recommendation: Focusing on strengthening exercises of the abdominal and lower back muscles ensuring the efficacy and stability of the vertebral column.

Keywords: different positions - tennis performance - vertebral column morphology

1. INTRODUCTION

The main axis of the body is the vertebral column. The vertebral column plays an important role in body movement .It is made of bones and cartilage and it gives the body its posture and strength. plays an important role in body movement .It is made of bones and cartilage and it gives the body its posture and strength. The structure of the bones suits their mechanical function whether static or dynamic. Bones are linked together by joints that act like levers and with the help of muscles; they complete the desired movement and maintain the body balance (2).

The vertebrae grow by the same magnitude in height and width at the age of three. The vertebrae and spinal canal grow quickly till the age of 5 and the body growth continue till the end of high school. Most of the cervical, thoracic and lumbar vertebrae growth are completed by the age of 20,the sacrum vertebrae grow until 25 years and the coccyx vertebrae growth is completed by the age of 30 (20).

When we look to the vertebral column in a sagittal position (front–back),we will find that the vertebral column is composed of 4 physiological curvatures 2of them heading forward (cervical and lumbar) and called lordosis Kurt et.al (2003) and Sean Hanrahan (2005) . The other 2 heading backward (thoracic and sacrococcyx) and called kyphosis. These curvatures are strengthened due to the strength of the muscles, joints and cartilages. The cervical and thoracic curvatures are completed at the age of 7 and the lumbar curvatures are completed at the age of 12.The complete growth of the vertebral column happens at the age of 18 -20 and its main function is to maintain the body balance around an equal axis between the different curvatures (17).

The skills training for the different sports depend on a group of theoretical basics and scientific rules related to the human body's activities which must be practically adopted to explain the body balance and movement .This is done through the study of the skeletal-muscular system morphology which will enable trainers to provide proper training (2).

Athletics have special features in the vertebral column curvatures depending on the type of sport practiced. Tennis is considered an acyclic non repetitive sport depending on one side movement .The trunk movements during performance varies between quick flexions and extensions from the sagittal spinal position. The high training loads with repetitive movements in the trunk lead to morphological changes of the vertebral column for example affecting the lumbar vertebrae ,tension of the abdominal and lumbar muscles in addition to an increased risk of injury due to increased inner pressure on the vertebrae (12).

Many studies have been done on the effect of the athlete's different positions during performance on the morphology of the vertebral column. Rowing, volleyball and water skiing involve quick repetitive flexion and extension of the trunk (6, 4, 21). In addition, cyclists during performance are forced into the flexion position which affects their trunk. Athletes in sports with frontal curvature positions e.g cyclists ,skiers ,and canoeists have been found to have kyphosis during standing position while canoeists have decreased thoracic and lumbar curvatures in sitting position (5,10).

These studies are only done by modern computerized devices to be able to give specific information .The Spinal Mouse device measures the angles between the vertebrae in the whole vertebral column except the cervical section . It discovers any deviation in the vertebral column and compares them to the normal measurements according to age and sex .It is an important device in the sports field and all studies are performed on it.

This research studies the vertebral column morphology for tenins players .The researcher finds that tennis exerts morphological changes on the vertebral column .The aim of this study is to know the effect of tennis on the vertebral column and the incidence of scoliosis occurring to tennis players.

Aim of the research

1- Identify the vertebral column morphology of to tennis players at the following points :

A- Throacic section

B- Lumbar section

C- Sacral section

2- Identify incidence of scoliosis occurring to to tennis players.

Questions of the research:

A- Is there any statistical significance in the vertebral column morphological measurements of the thoracic section for to tennis players?

B- Is there any statistical significance in the vertebral column morphological measurements of the lumbar section for to tennis players?

C- Is there any statistical significance in the vertebral column morphological measurements of the sacral section for to tennis players?

D- Is there any statistical significance in the vertebral column morphological measurements of scoliosis for to tennis players?

Research Terminology :

Flexion of the vertebral column: It is the maximum curvature of the vertebral column to the front (13).

Extension of vertebral column: It is the maximum curvature of the vertebral column to the back (13).

(Lumbar/Spinal) : Total lumbar section.

(Thoracic/Spinal) : Total thoracic section.

(Sacrum/hip) : Total sacral section.

(Incl) : Vertebral column inclination.

(length) : General vertebral column.

Related Studies Studies

José M. Muyor et.al (2013) evaluated sagittal thoracic and lumbar spinal curvatures and pelvic tilt in elite and master cyclists when standing on the floor, and sitting on a bicycle at three different handlebar-hand positions. A total of 60 elite male cyclists (mean age: 22.95 ± 3.38 years) and 60 master male cyclists (mean age: 34.27 ± 3.05 years) were evaluated. The Spinal Mouse system was used to measure sagittal thoracic and lumbar curvature in standing on the floor and sitting positions on the bicycle at three different handlebar-hand positions (high, medium, and low). The mean values for thoracic and lumbar curvatures and pelvic tilt in the standing position on the floor were 48.17 ± 8.05º, -27.32 ± 7.23º, and 13.65 ± 5.54º, respectively, for elite cyclists and 47.02 ± 9.24º, -25.30 ± 6.29º, and 11.25 ± 5.17º for master cyclists. A high frequency of thoracic hyperkyphosis in the standing position was observed (58.3% in elite cyclists and 53.3% in master cyclists), whereas predominately neutral values were found in the lumbar spine (88.3% and 76.7% in elite and master cyclists, respectively). When sitting on the bicycle, the thoracic curve was at a lower angle in the three handlebar-hand positions with respect to the standing position on the floor in both groups ($p < 0.01$). The lumbar curve adopted a kyphotic posture. In conclusion, cyclists present a high percentage of thoracic hyperkyphotic postures in standing positions on the floor. However, thoracic hyperkyphosis is not directly related to positions adopted on the bicycle (11).

José M. Muyor et.al (2011) stated that sports with a predominance of forward bending and extension postures have been associated with alterations in the sagittal spinal curvatures and greater risk of spinal injury. Because, the tennis players adopt these postures, the aims of this study were: 1) to describe spinal curvatures and pelvic tilt in male and female highly trained adolescent tennis players during relaxed standing posture and with thoracic spine corrected (in prone lying on the floor); and 2) to determine the frequency of thoracic hyperkyphosis and lumbar hypo/hyper lordosis in these postures. Forty adolescent tennis players (24 male and 16 female) aged 13-18 years, participated voluntarily in this study. The Spinal Mouse system was used to measure sagittal spinal curvatures and pelvic tilt. The mean values in the relaxed standing posture were 43.83° ± 7.87° (thoracic kyphosis), - 27.58° ± 7.01° (lumbar lordosis), and 13.38° ± 5.57° (pelvic tilt) for male tennis players, respectively; and 36.13° ± 6.69° (thoracic kyphosis), - 32.69° ± 5.06° (lumbar lordosis), 20.94° ± 5.36° (pelvic tilt) for female tennis players ($p < 0.05$ between genders in all spinal parameters). The male and female tennis players showed a frequency of 62.5% and 93.8% ($p = 0.032$) for neutral thoracic kyphosis, and 83.3% and 93.8% ($p = 0.062$) in neutral lumbar lordosis, respectively. In conclusion, due to the high percentage of neutral spinal curvatures in both male and female tennis players, to practice tennis in these levels does not alter sagittal spinal morphology in the relaxed standing posture in adolescent highly trained tennis players(9).

Pedro A. Lopez- Minarro et.Al (2011) determined that the sagittal spinal curvatures and pelvic position in standing and kneeling in the canoe in young canoeists. Forty-four young highly-trained canoeists (mean age: 15.11 0.61 years) were recruited. Thoracic and lumbar curvatures and pelvic inclination were evaluated with a Spinal Mouse system in standing position and in the base position (kneeling on one knee in the canoe) and catch phase of the stroke. The mean thoracic kyphosis, lumbar lordosis and pelvic inclination in standing were 44.66 ± 8.80º, -30.34 ± 8.31º, and 14.20 ± 7.32º, respectively. In the canoe, the thoracic, lumbar and pelvic angles were 39.66 ± 9.52º, -24.32 ± 6.79º, and 15.18 ± 4.34º, respectively, for the base position ($p<0.001$ with respect to standing, except for pelvic inclination), and 28.93 ± 10.45º, -13.45 ± 10.60º, and 37.61 ± 6.27º, respectively, for the catch phase of the stroke ($p<0.001$ with respect to standing and base position). A higher percentage of hyperkyphotic postures in standing than in the canoe was found, while thoracic hypokyphosis increased in the catch phase of the stroke. In regards to the lumbar curve, the percentage of hypolordosis postures in the base position was higher than when standing. Lumbar kyphotic postures were detected in the catch phase of the stroke. In conclusion, the standing thoracic hyperkyphosis in young canoeists may be related to factors other than the posture and movement in the canoe. The canoeists adopted a lumbar flexed posture at the catch phase of the stroke, although this position may not affect the sagittal configuration of lumbar spine in standing. Postural training should be included in the training program of canoeists to improve the thoracic posture in the standing position (12).

Elizabeta Popova Ramova et.al (2011) stated that the spine deformities are presented with 27.3% in the population regarding all deformities of the muscle system. The clinical examination has its limitations as a result of the subjective participation of the examiner and the lack of qualitative measurement. The research tested the applicability of the software program Spine Mouse in screening of the spine deformities. The software program is important for spine examination in the sagittal plane. In order to evaluate the software in the screening program for bad posture, a score has been made with maximum points and possible gained points regarding the parameters: number of children who participated in the examination out of the entire population, number of the examined, preserved data from the examination and cooperation during the examination. A total of 986 children were examined for 15 days with 6 children examined per hour or 74%. Of the total number of children, 97.2% cooperated during the examination and the data were lost for 14.7%.The results showed that this software is applicable with significance for examination of spine deformities in the school population. The cost of the software and the speed of the examination are limiting factors for its use in a large population(5).

Nevine Fikry (2008) studied the vertebral column morphological difference and the balance of movement between male and female tennis players. The researcher studied 10 players (5male and 5female) with an average height of 155cm ,average weight 49.80 kg and average age13.7 years old.The researcher used the Spinal Mouse device . The researcher concluded that the lumbar vertebrae were the most affected in the players.The female players showed higher balance of movement which is due to the growth and physiological changes that happen at this age . The total balance factor was the same for both male & female players. She recommended the use of calibrated modern devices to evaluate the performance and morphology of the players every 3-6 months (9*)*.

Research Procedure :

1-Research Methodology : The researcher used descriptive method as it suits the nature of the research .

2- Research Sample : The sample has been chosen by the selective method and it is composed of 15 players from Sultan Qaboos University tennis Team. The following table refers to the characteristics of the sample .

Table 1- Descriptive characteristics of the sample

Parameters	Mean	Standard deviation	Skewness
Age (years)	19.18	2.71	1.24
Height (cm)	180.7	6.54	0.12
Weight (kg)	71.87	9.33	0.42
Training (years)	10.62	2.18	1 .23

3-Research procedure :

The required procedures were prepared to perform the test at the laboratory of the Physical Education department, College of education, Sultan Qaboos University on 12/11/2015 to evaluate the vertebral column of the research sample.

Tools and Devices :

Spinal Mouse

The device is a wireless unit used to measure the angles between the vertebrae of the whole vertebral column except the cervical section . It also discovers any deviations and compare it to the normal vertebra which is calibrated in the computerized unit according to age and sex , that is why it is considered one of the modern important devices in the sports field .The device has different tests but the researcher chose 6 tests suitable for the nature of the research :

1-Testing vertebral column in upright standing position.

2- Testing vertebral column frontal curvature – flexion position.

3- Testing vertebral column backward curvature – extension position.

The previous tests investigate the research 's first objective with its 3criterias

(attachment 1) .

The following tests investigate the second objective of the research

(attachment 2) .

1- Testing vertebral column in upright standing position 2.

2- Testing vertebral column in upright standing position and bending towards the right (Upright – Right).

3- Testing vertebral column in upright standing position and bending towards the left (Upright - Left).

The following data were obtained for each position in the 6 tests :

1-The measure of the angles between 2 adjacent vertebrae .

2-The angles for the vertebral column curvatures.

3-The length of each section of the vertebral column from the first thoracic till the sacrum.

4-Total lumbar section (Lumbar/Spinal).

5-Total thoracic section (Thoracic/Spinal).

6-Total sacral section (Sacrum/hip).

7-Vertebral column inclination (Incl).

8-General vertebral column (length).

The Device is composed of 2 main units:

1-The unit that moves along the vertebral column.

2-The unit attached to the computer.

The unit attached to the computer transmits the signal to the computer program for data analysis and it's calibrated to the 3 testing positions. The players data is entered on the computer program and then the testing position is selected from the screen .Press the left button to start and slowly move down the vertebral column starting from the first vertebra in the thoracic spinal till the sacrum vertebra and then press the left button to finish the test . The shape of the vertebral column is then shown on the screen . The same steps are done for tests 2 and 3.At the end the results of the vertebral column is shown.

Rules for testing the vertebral column:

1. Excluding any player who had previously complained or suffered from pain in the vertebral column.
2. Identifying the standing position by making a mark on the floor.
3. Maintaining the distance between the player and the device by 1 meter.
4. Making marks on the vertebral column while conducting the test for precision in case the device gets off track ,then an error will show on the computer screen , so the test will be repeated.
5. Keeping the hands still next to the body during the testing.

Statistical Measurements:

1-Mean .

2-Standard deviation.

3- Skewness

4-Sperman correlation factor.

5-Pearson correlation factor.

2. Results:

Table 2-Measurments of the vertebral column of the sample in standing position

Parameters	Mean	Standard deviation	Skewness
Thor 1/2	2.6667	2.46885	2.020
2/3	3.3333	2.60951	.580
3/4	4.5333	3.70071	.554
4/5	4.4000	2.19740	.062
5/6	4.3333	2.66369	.737
6/7	3.8667	2.16685	.294
7/8	5.2000	2.21037	.533
8/9	5.6000	2.38447	-.945-
9/10	5.7333	2.31352	.334
10/11	4.6667	2.71679	-.013-
11/12	1.7333	1.57963	.507
Lumb 1/12	1.9333	1.86956	.943
1/2	3.3333	2.49762	2.069
2/3	3.8000	2.21037	.245
3/4	5.0000	1.96396	-.261-

4/5	7.1333	1.76743	-.411-
Sacr 1/5	6.0000	2.00000	.247
SAC\HIP	4.6667	2.31969	-.047-
TH\SP	30.2667	17.28528	1.613
L\SP	41.3333	7.42262	.565
INCL	5.299332	61.59947	.065
LENGTH	5.299332	61.59947	.065

Table 2 shows the measurements of the vertebral column angles for the sample in standing position. The skewness ranged between ±3 which indicates homogeneity of the sample.

Table 3- Measurments of the vertebral column of the sample in flexion position.

Parameters	**Mean**	**Standard deviation**	**Skewness**
Thor 1/2	4.8667	3.44065	.361
2/3	3.4667	2.03072	.144
3/4	4.1333	3.48193	1.195
4/5	4.0667	3.15021	.894
5/6	3.6667	3.35233	1.096
6/7	3.9333	2.40436	1.157
7/8	3.2000	1.56753	.262
8/9	5.8000	3.00476	.295
9/10	5.8667	2.09989	1.057
10/11	6.5333	1.55226	1.845
11/12	5.6667	2.66369	.074
Lumb 1/12	4.8667	2.09989	.683
1/2	5.9333	3.15021	-.072-
2/3	9.4667	4.38938	.813
3/4	11.4667	6.82293	1.490
4/5	11.1333	6.04893	1.779
Sacr 1/5	5.7333	4.11386	1.534
SAC\HIP	1.0867	11.58612	-.304-
TH\SP	38.1333	10.54830	.518
L\SP	48.7333	10.95749	-.360-
INCL	6.1233	46.63026	.528
LENGTH	5.2993	61.59947	.065

Table 3 shows the measurements of the vertebral column angles for the sample in the flexion position. The skewness ranged between ±3 which indicates homogeneity of the sample.

Table 4-Measurments of the vertebral column of the sample in extension position.

Parameters	Mean	Standard deviation	Skewness
Thor 1/2	3.9333	2.40436	-.337-
2/3	3.6667	2.49762	-.101-
3/4	4.5333	3.06749	-.037-
4/5	5.7333	4.04381	.889
5/6	4.0000	2.39046	.290
6/7	5.0667	2.93906	.197
7/8	5.6000	2.55790	-.134-
8/9	6.8667	2.89992	-.152-
9/10	6.0000	2.47848	.000
10/11	4.0000	2.80306	.337
11/12	3.5333	2.29492	.871
Lumb 1/12	3.4667	2.13363	-.354-
1/2	4.8667	2.19957	.241
2/3	6.6000	1.91982	-.246-
3/4	8.2000	2.21037	.304
4/5	10.2667	3.47371	-.683-
Sacr 1/5	9.3333	4.56175	1.954
SAC\HIP	26.06	10.47082	-.144-
TH\SP	40.7333	9.67668	-.196-
L\SP	44.8000	15.85740	.173
INCL	5.1113	52.29568	.000
LENGTH	5.2993	61.59947	.065

Table 4 shows the measurements of the vertebral column angles for the sample in the extension position .The skewness ranged between ±3 which indicates homogeneity of the sample.

Table 5-Mean difference between the 3 positions(standing-flexion-extension)

Parameters	Standing	Flexion	Extension
SAC\HIP	4.661	1.086	26.06
TH\SP	30.26	38.13	40.73
L\SP	41.33	48.73	44.80
INCL	5.299	6.123	5.111
LENGTH	5.299	5.299	5.299

Table 5 shows the mean difference between the 3 positions. It shows the curvature of the lumbar section in the flexion position and the curvature of the thoracic and sacrum section in the extension position.

Table 6-The relation between the thoracic,lumbar and sacrum in the 3 positions using Pearson correlation factor.

Correlation between the 3 positions(Pearson)	
Correlating Point	**Correlation**
(Lumbar/Spinal) Stand &Flex	.871
(Lumbar/Spinal) Stand &Exten	.728
(Lumbar/Spinal) Exten &Flex	.629
(Thoracic/Spinal) Stand &Flex	.843
(Thoracic/Spinal) Stand &Exten	.863
(Thoracic/Spinal) Exten &Flex	.373
(Sacrum/hip) Stand &Flex	.657
(Sacrum/hip) Stand &Exten	.098
(Sacrum/hip) Exten &Flex	.536

Table 6 shows Pearson correlation factor indicating there is a statistical significance between the sacrum extension and sacrum standing position equal to 0.98 which is a strong relation as it approaches 1.

To confirm the relation the researcher used Spearman correlation factor:

Table 7- The relation between the thoracic, lumbar and sacrum in the 3 positions using Spearman correlation factor.

Correlation between the 3 positions(Spearman)	
Correlating Point	**Correlation**
(Lumbar/Spinal) Stand &Flex	**.888**
(Lumbar/Spinal) Stand &Exten	**.860**
(Lumbar/Spinal) Exten &Flex	**.629**
(Thoracic/Spinal) Stand &Flex	**.881**
(Thoracic/Spinal) Stand &Exten	**.869**
(Thoracic/Spinal) Exten &Flex	**.515**
(Sacrum/hip) Stand &Flex	**.434**
(Sacrum/hip) Stand &Exten	**.145**
(Sacrum/hip) Exten &Flex	**.680**

Table 7 results matches with the results of Pearson correlation factor.

Table 8- Measurments of the vertebral column of the sample in standing position 2.

Parameters	Mean	Standard deviation	Skewness
Thor 1/2	2.2000	2.48424	1.543
2/3	2.0000	1.92725	.760
3/4	1.9333	1.70992	2.097
4/5	1.2667	1.62422	1.927
5/6	1.2667	1.48645	1.580
6/7	1.3333	1.58865	2.325

7/8	1.8000	1.78085	1.047
8/9	1.4667	1.06010	.100
9/10	1.8000	1.08233	.062
10/11	1.8667	1.72654	1.965
11/12	2.0000	1.73205	1.142
Lumb 1/12	1.7333	1.94447	.904
1/2	2.0000	1.88982	.513
2/3	1.5333	1.72654	.848
3/4	2.0000	1.85164	1.714
4/5	2.5333	1.64172	1.329
Sacr 1/5	2.5333	1.95911	.107
SAC\HIP	3.5333	2.79966	1.075
TH\SP	5.0000	3.74166	.821
L\SP	2.7333	1.38701	-.005-
INCL	5.277332	48.33731	.291
LENGTH	5.299332	61.59947	.065

Table 8 shows the measurements of the vertebral column angles for the sample in standing position 2.The skewness ranged between ±3 which indicates homogeneity of the sample.

Table 9- Measurments of the vertebral column of the sample in the tilted position towards the right.

Parameters	Mean	Standard deviation	Skewness
Thor 1/2	2.8000	2.56905	1.801
2/3	2.0000	1.55839	.261
3/4	1.9333	1.66762	.974
4/5	2.6000	1.40408	-.236-
5/6	2.0667	1.16292	-.146-
6/7	2.8667	2.35635	2.149
7/8	2.5333	1.50555	-.074-
8/9	3.2000	2.14476	1.055
9/10	3.4000	1.84391	.893
10/11	4.0000	1.73205	-.476-
11/12	3.6000	1.84391	-.025-
Lumb 1/12	3.1333	1.84649	.247
1/2	3.2667	2.57645	.325
2/3	5.0000	3.09377	1.269
3/4	5.5333	3.35659	.561
4/5	3.4000	2.72029	.470
Sacr 1/5	3.5333	1.27395	1.532

SAC\HIP	25.8667	8.81449	.106
TH\SP	19.4667	8.80638	.391
L\SP	35.1333	7.79071	.691
INCL	5.212772	58.49965	.371
LENGTH	5.299332	61.59947	.065

Table 9 shows the measurements of the vertebral column angles for the sample in the tilted position toward the right. The skewness ranged between ±3 which indicates homogeneity of the sample.

Table 10- Measurments of the vertebral column of the sample in the tilted position towards the left.

Parameters	Mean	Standard deviation	Skewness
Thor 1/2	3.0667	1.79151	-.115-
2/3	2.1333	1.55226	.671
3/4	3.0000	2.10442	.424
4/5	2.5333	1.68466	.761
5/6	2.5333	1.55226	.391
6/7	2.6000	1.63881	.526
7/8	2.8000	1.97122	1.224
8/9	3.1333	2.61498	1.437
9/10	4.0667	1.79151	.057
10/11	3.2667	2.63131	.779
11/12	4.2000	1.78085	-.259-
Lumb 1/12	3.6000	2.19740	.731
1/2	3.6667	2.38048	-.166-
2/3	5.1333	3.20416	-.019-
3/4	4.7333	2.12020	.922
4/5	6.6000	4.11964	.358
Sacr 1/5	6.8667	3.60291	.283
SAC\HIP	24.5333	10.24602	-.432-
TH\SP	28.8667	9.55336	1.218
L\SP	34.3333	6.16055	.667
INCL	5.217332	51.63673	.389
LENGTH	5.299332	61.59947	.065

Table 10 shows the measurements of the vertebral column angles for the sample in the tilted position toward the left. The skewness ranged between ±3 which indicates homogeneity of the sample.

Table 11-Mean difference results for the 3 positions(standing 2-tilting to the left-tilting to the right)

Parameter	Standing position 2	Tilting to the left	Tilting to the right
INCL	5.27	5.21	5.21
LENGTH	5.29	5.29	5.29

Table 11 shows the mean difference between the 3 positions indicating there is no difference between the curvatures of the vertebral column and the same length of the measured part of the vertebtral column in both directions.

3. DISCUSSION:

The data analysis and presentation of the vertebral column testing's shown in table 5 (the mean difference of the 3 positions in the extension position) shows that there is a higher mean difference for the thoracic and sacrum section indicating that they were the parts affected during fencing performance . This data is also confirmed using Pearson and Spearman correlation factors (tables 6,7).

Alirckson and Warner (2006) indicate a statistical increase in the thoracic kyphosis of skiers after 5 years. Ogrowska (2007) found a change in the sacrum section of rowers training from 8-20 year. Per A. (2002) indicates that high level players have stronger abdominal muscles than the lower back muscles which is the opposite for non training people. This agrees with table (1) that indicates the training period of the sample which reaches 12 years (2,13,15).

The number of years performing with continuous high training loads is an important factor in determining the curvatures of the vertebral column .The yearly increase in loads is proportional to the increase in the thoracic curvature in different sports. This matches with what Smith (2008) mentioned that high training loads may lead to loss of the disc height which reduces the length of the anterior column of the spine. This will result in thoracic kyphosis leading to low back pain (sacrum section) as well as bringing the scapula in an anterior tilt and protracted position so restricting the shoulder range of motion (18).

The data analysis and presentation of the vertebral column testing's shown in table 5 (the mean difference of the 3 positions in the flexion position) shows there is a mean difference for the lumbar section curvature indicating that it is one of the affected areas during performance. This was also confirmed by Pearson & Spearman factors (table 6,7).

Stuart McGill (2016) indicate that the flexion exercise in the thoracic section , the range of motion is less than in the lumbar section 30-40 degrees due to the presence of the thoracic cavity .The range of motion is greater in the lower section of the back because the lower ribs are longer and freely moving . While the lumbar vertebrae range of motion are relatively free 55 degrees which is less than the sacrum vertebrae range of motion . The link between the lumbar and sacrum sections are responsible for the greater part of motion (20,1).

Robert Behnke (2012) and Young J.L (1996), explained that the flexion in the standing position depends to a great extent on the earth's gravity . The extensor muscles of the vertebral column facilitates this movement as well as the increase of the pull on the posterior part of the annulus fibrosis , the longitudinal posterior ligament , and the ligament flava (17,22) .

Burri C.&Ruter.A (2000), Stuart McGill (2016) confirmed that practical measurements showed that the load on the intervertebral discs upon lifting is less than the calculated load by 30% at the intervertebral disc between the fifth lumbar and the first sacral and less by 50% in the lower thoracic section.This is because the abdominal muscles absorbs this difference due to the strong contraction during lifting (3,20) .

This is also confirmed by Jose Muyor et.al (2013) indicating that the pelvic area is the base of the vertebral column and the frontal curvature of the pelvis increases the curvature of the lumbar section. While the backward curvature of the pelvis decrease the lumbar curvature (8) .

Table (11) presenting the mean differences of the 3 positions (standing 2- tilting towards the right and left) states that the inclination and the length of the measured vertebrae are the equal for both sides(5.21) indicating that there is no scoliosis in the sample .The researcher states that this is because the players focus on performing prophylactic exercises to avoid any tilting to the left and right side .

The researcher highlights the importance of applying training programs for all aspects of the vertebral column, not only the for the right and left sides that receive most of the pressure during the training period. In addition strengthening the abdominal and lower back muscles will help in protecting the vertebral column from the encountered loads during training. Finally all these programs would help in the protection of the vertebral column from any deviations or injuries that may result from practicing fencing.

4. CONCLUSION:

The following have been concluded according to the research objectives and the sample :

1- The lumbar section is affected by the performance of tennis in the flexion position.

2- The thoracic and sacrum sections are affected by the performance of tennis in the extension position.

3- There is no change or deviation in the angles between the vertebrae whether towards the right or the left caused by the performance of tennis in the standing position.

5. RECOMMENDATIONS:

1- Using vertebral column measurements and testing in different positions as an indication for early detection of any abnormal inclinations.

2- Focusing on the strengthening exercises of the abdominal and lower back muscles to ensure the efficacy and the stability of the vertebral column.

3- Considering prophylactic programs to ensure avoiding any postural deformations that may occur due to playing the sport whether in sagittal or coronal plane of the vertebral column .

4- The importance of making the players and their parents aware of the postural changes that might happen from the sport and what will happen if they don't support the trainers in educating their children to follow proper postures .

5- Continuously identifying changes that happen to the vertebral column to be able of developing the training programs .

6- Testing other body joints for example knees and shoulders.

7- Conducting similar research studies on other sports especially young players.

8- Using advanced devices to evaluate the players every 6 months to assess their morphological state

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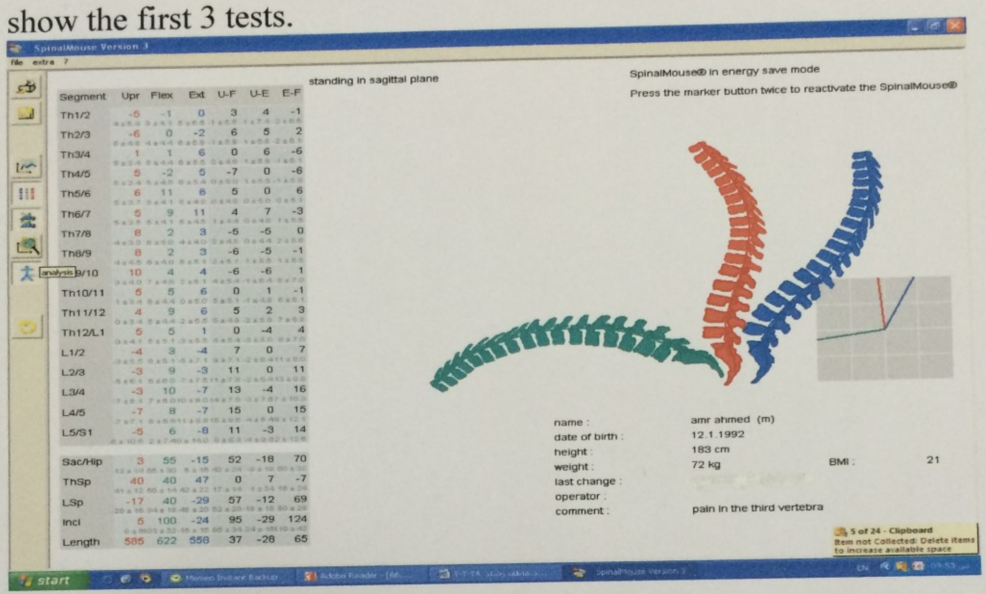
Attachments

Attachment 1:Picture of the results from the Spinal Mouse device to show the first 3 tests.



Attachment 2: Picture of the results from the Spinal Mouse device to show the tests from 4 to 6.