BIOMECHANICAL EFFECT OF TESTING POSITIONS ON HAND GRIP STRENGTH

WALAA M. EL-SAIS* and WALAA S. MOHAMMAD†‡

*Department of Physical Therapy
College of Applied Medical Sciences
Majmaah University, Saudi Arabia

†Department of Biomechanics
Faculty of Physical Therapy, Cairo University
7 Ahmed Elziat Street, Bean Elsariate
Faculty of Physical Therapy, Giza, Egypt
‡rawanl_walaa@yahoo.com

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Hand grip strength (HGS) is a useful functional measure of the integrity of the upper extremities, however, many studies have examined it from selected positions (i.e., supine, sitting, standing), with no emphasis on other derived positions that are used in clinical setting. This study’s objective was to evaluate HGS in different body positions that are used in clinical setting by using a standard protocol. The study sample was a convenience sample of 40 healthy male participants with no history of psychiatric, neurological, or upper extremity orthopedic dysfunction. Grip strength in the dominant hand was measured with a Jamar Plus+ digital hand dynamometer in five positions: Supine, prone, side-lying, sitting, and standing. The HGS value in prone position was significantly lower than in standing position \( (p = 0.043) \) and sitting position \( (p = 0.013) \). However, no statistically significant difference was found in HGS among the supine, prone, and side-lying positions. Grip strength was moderately correlated with age \( (r = 0.643) \). This study provides useful evaluation for grip strength in different positions. In identical upper extremity positions, grip strength varies between different body positions. Grip strength is equivalent when tested from the supine, side-lying, or prone positions, thus the position can be adjusted according to the patient’s condition. Finally, age is an important determinant of hand grip evaluation, particularly when standing position is used.

Keywords: Digital hand dynamometer; grip strength; body positions.

‡Corresponding author.
1. Introduction

Hand grip strength (HGS) measurement is useful in the assessment of individuals who are suffering from impairments in daily life tasks, measurement of the integrity of upper extremity function, and effectiveness of hand rehabilitation procedures.\textsuperscript{1,2} The measurement of such impairment is achieved through a comparison between subject’s grip strength with established norms. There are many factors influencing the degree of grip strength produced, however, it is of importance to measure grip strength in a body position that is identical to that used in normative studies.\textsuperscript{3}

The American Society of Hand Therapists (ASHT) recommended a testing protocol in which the subject is seated upright against the back of a chair with feet flat on the floor. The shoulder was adducted and neutrally rotated, the elbow flexed at 90° and the forearm in neutral and wrist between 0° and 30° of extension.\textsuperscript{4} However, there is no assent on the optimal body posture or positions of the shoulder, elbow and wrist for measuring HGS. Moreover, the need for a standard protocol will improve the validity of assessment as assuming a comfortable position produced significantly different readings from the ASHT protocol.\textsuperscript{5}

A previous study examined whether grip strengths were different when measured in supine and sitting positions, and found similar grip strengths in both positions.\textsuperscript{1} Another study measured HGS in the supine and sitting positions and found that grip strength measurements were significantly greater in sitting (with elbow unsupported) than those in bed and in sitting (with elbow supported).\textsuperscript{3} A recently published study evaluated the grip strength of boys and girls in two positions; standing with elbow in full extension, and sitting with elbow in 90° flexion and found that grip strength with elbow flexed was higher in boys, but girls had higher grip strength values with elbow extended.\textsuperscript{2}

The previous studies cited showed differences in maximum HGS in different upper limb or subject positions.\textsuperscript{1,6,7} The possible causes for changes in strength may be related to variation in muscle force capacity resulting from changing muscle length, which is related to upper limb posture. Other studies\textsuperscript{1,6} examined HGS either in two positions with flexed elbow or different body positions (standing, sitting and supine),\textsuperscript{8,9} though they did not use the same standardized protocol (for upper extremity) to measure grips in both sitting and supine positions. Thus, comparisons to established norms can only be made when the arm position is invariant. To know when individual test results can be compared with established norms, one must know which body position produces equivalent grip strengths and which leads to altered grip strength.

Despite the importance of normative data of HGS for occupational and clinical practice, many studies examined it from selected positions (supine, sitting and standing), with no emphasis on other derived positions that are used in a clinical setting and other studies did not use a standardized testing procedures in their research work. These derived positions are of practical value for patients in acute...
care or long-term care who are confined to bed, when the patient unable to tolerate an upright position (such as patient with spinal cord injury).

Thus, there is a need for assessing HGS from different body positions to allow clinicians to establish objective goals, address both physical and functional limitations, establish a methodology that is clinically relevant, easy to perform and reproducible and guide a rehabilitation program to return to function. The purpose of our study was to evaluate the HGS in healthy male adults in the supine, side-lying, prone, sitting and standing positions.

2. Methods

2.1. Subjects

The study was conducted after obtaining approval from the research ethical committee. Above 40 volunteering males aged between 19 and 22 years were assessed. Exclusion criteria included a history of any neurologic or orthopedic conditions that could affect their grip strength, past or present pathology or trauma to upper extremity or cervical region. All subjects were assessed in this study in a random order.

The number of subjects was determined a priori based on statistical power analysis to ensure type I error did not exceed 0.05 and type II error did not exceed 0.20. This analysis indicated that 22 subjects were required to find a power of 96% and level of significance of 95%.

The Jamar Plus+ Digital Hand Dynamometer, 200Ib (Sammons Preston Rolyan, Bolingbrook, IL, USA) was used to measure the HGS from different body positions. The Jamar dynamometer is a validated and reliable tool for measuring HGS in a clinical setting. The handle of a grip dynamometer typically allows adjustment of grip size.

2.2. Protocol

HGS was measured according to a standard protocol based on the recommendations of the ASHT, using the second handle of the Jamar dynamometer. The second handle position has been assumed to be the most reliable and consistent position and produces maximal grip strength. HGS tested for all body positions of all subjects was conducted in a randomized order (randomly assigning each subject to one of five measurement position) to prevent dependent ordering effect. The subject position in ASHT testing protocol is seated upright against the back of a chair with feet flat on the floor. The shoulder was adducted and neutrally rotated, the elbow flexed at 90° and the forearm in neutral and wrist between 0° and 30° of extension.

In the sitting position (Fig. 1), the testing position recommended by the ASHT was used. The subject was instructed to be seated with shoulder adducted and neutrally rotated, elbow flexed 90°, forearm in mid-prone and wrist in neutral to 30° extension (wrist in slightly extended position), with neutral radioulnar deviation for
optimal performance in power grip ASHT.\textsuperscript{4} In supine position (Fig. 2), the same upper extremity position was used, but the subject was lying with his body aligned (legs straight and feet apart). The tester held the dynamometer at the base and around the readout dial to prevent accidental dropping. In prone position (Fig. 3), the same upper extremity position was used, but the subject was lying on his abdomen with his forearm outside bed. In side-lying position (Fig. 4), the same upper extremity position was used, but the subject was lying on his side with the tested hand above. In standing position (Fig. 5), the same upper extremity position was used, but the subject was standing with the forearm unsupported.

Before testing, the examiner demonstrated how to hold the handle of the dynamometer. The same instructions were given for each trial. After the subject was

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Fig. 1. Testing hand grip from sitting position.

Fig. 2. Testing hand grip from supine position.
positioned with the dynamometer, the examiner instructed the subject to squeeze the handle maximally and to sustain this for 3–5 s with a rest of 15–20 s between measurements. The examiner told the subject to squeeze the dynamometer as hard as possible and gave verbal encouragements to squeeze harder during the test.

Three successive measurements were taken for dominant hand and the maximum of the three grips was recorded, as the dominant hand has a 10% stronger grip than the nondominant hand for right-handed people. The maximum value was taken instead of the average value for many reasons; to avoid problem that could arise due to fatigue of the muscle, also the maximum value used to test reliability of handgrip, as well as the maximum method have commonly been used by other investigators.

2.3. Data analysis and statistical analysis

The descriptive statistics of age, body mass index (BMI) and HGS were recorded. HGS measurements were recorded by taking the maximum value of the three

Fig. 3. Testing hand grip from prone position.

Fig. 4. Testing hand grip from side-lying position.
successive trials for each subject. Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 20.0. One-way repeated-measures analysis of variance (ANOVA) was used to compare the difference in the HGS between different body positions. Level of significance for all tests was set at 0.05. The correlation between dependent variable HGS among each position and independent variables age was analyzed through Pearson product moment correlation coefficient ($r$).

3. Results

HGS was recorded for 40 participants. Demographic details are presented in Table 1. All participants were males and right-hand dominant. The HGS measurements for the supine, prone, side-lying, sitting and standing positions are shown in Table 2. The higher grip strength was observed in standing position. ANOVA revealed that there was significant differences in HGS measurements ($F = 6.366, p = 0.014$). The HGS value in prone position was significantly lower than that in standing position ($p = 0.043$) and the sitting position ($p = 0.013$). On the other hand, there was no significant difference between the other body positions ($P > 0.05$).

Regarding the standing position, there was a significant moderate positive correlation between HGS and age ($r = 0.643, p = 0.002$). However, there was non-significant correlation between the HGS and age ($p > 0.05$) for all remaining positions.
4. Discussion

This is the first study investigating the HGS among healthy male adults in five different body positions, including fundamental and derived positions with the upper extremity of the tested hand in the position recommended by the ASHT, on peak maximal grip strength. It is of high importance to achieve early mobilization of patients; however, some patients cannot tolerate the upright position, and others perform strengthening exercises from recumbent positions. Their positions may affect hand grip measurement for evaluation and treatment. Therefore, testing the HGS from different positions is of clinical importance.

In this study, the higher HGS value was found in the standing position while the lowest in prone position. The findings of the current study indicated nonsignificant differences among standing, sitting and supine, however, the higher value of HGS was obtained from standing and sitting positions. These findings are in close agreement with the results of previous studies\(^2,19\) who found that a greater strength was obtained when the subjects were standing compared to the sitting position. On a physiological basis, this may be due to the increased temporal and spatial summation of the contracting muscles in the standing position. In addition, sitting position induces relaxation while standing position stimulates cortical and peripheral arousal. Furthermore, the synergistic effect of the lower extremity muscles and corresponding sensory feedback is greatest in standing rather than in sitting position.\(^19\)

The reference values for HGS based on the maximum of three successive trials in this study are lower than those reported by few studies.\(^20,21\) This difference may be attributed to the type of dynamometer used, different populations of subjects, and different testing positions as the previous study\(^20\) used the testing position recommended by ASHA for some subjects and the standing position for others. Although the ASHT recommends the mean method,\(^4\) the maximum method has commonly been used by other investigators.\(^16,20,22\)
This findings are in close agreement with the results of previous reports\(^3\)-\(^8\) who found that a maximal grip strength is highest in sitting rather than in supine position. From a biomechanical perspective, when the upper limb is not supported, grip strength becomes stronger due to the synergistic actions of other muscles. By preventing wrist flexion, the synergists are able to maintain the joint in a position that allows the finger flexors to develop greater torque, a combination of optimizing sarcomere length and moment arm.\(^3\),\(^23\) This was contradictory to the previous study that revealed the grip strength measured in the sitting position was weaker than grip strength measured in supine position with no significant difference.\(^1\) This can be attributed to the fact that there was no attempt made to control wrist position when measuring grip strength, so the subjects adjusted their wrist position when moving between the testing positions, whereas the wrist flexion was found to give lower HGS.\(^7\) It may also be due to using the mean method rather than the maximum method for measuring the values of HGS.

The findings of HGS measurements in standing, sitting and supine position were in line with other studies.\(^2\),\(^3\),\(^8\),\(^19\) However, the main novel contribution of our study was that we studied the HGS in the previous fundamental positions with other derived positions (side-lying and prone), by using upper extremity position recommended by the ASHT. The HGS values in side-lying and prone positions for normal male subjects are unique to this study. The results demonstrated higher HGS value in side-lying than in prone positions with the absence of any significance between them.

One of the most interesting findings of this study is that only the HGS obtained in prone position was significantly lower than that in standing position and the sitting position. This may be due to the effect of gravity; the HGS significantly decreases as the gravitational force effect decreases. In all previous positions, the elbow was flexed to 90\(^\circ\). In standing and sitting positions, the subjects had to maintain their forearm position against gravity while it was with the gravity in prone position. In addition, the arm was perpendicular to the line of gravity in prone position.\(^1\)

Our study has particular relevance to injuries where the patient needs to be immobilized in bed (e.g., spinal cord injuries, fractures of lower extremities). Hence, HGS assessment and grip strength and endurance rehabilitation as a preparatory step for the gait training can be started early irrespective of the position of the patient, either in supine, side-lying or prone position.

Strengthening exercises for shoulder muscles — latissimus, trapezius and rhomboids — include holding weights or dumbbells on hands, which can be done from prone, sitting or standing position.\(^24\),\(^25\) Our results revealed that these exercises will be significantly influenced by the strength of the hand grip when done in prone, sitting or standing position. As a result, as a graduation for these exercises, the rehabilitation program for the previous muscles should be started from prone position where the HGS is less followed by sitting or standing position after gaining more strength in hand grip.
The same concept will be applied when doing strengthening exercise for shoulder abductor muscles using weights in hand from side-lying, sitting, or standing position. Such positions are antigravity position for the trained muscle; however, the grip strength will be less in side-lying that may hinder increasing the weight or resistance from this position.

The knowledge that the HGS value of sitting and standing positions (upright positions) was significantly higher than that of prone position, with no significant differences between standing and the sitting position values, can be incorporated into treatment techniques and functional activities. Patients who have weakened grip strength due to illness or injury should be instructed to adapt tasks that require increased grip strength to be performed in sitting or standing position. Repetitive work activities can also be adapted so that subject positioning provides maximal grip strength. This may decrease the effort required and reduce the occurrence of overuse injuries to the upper extremities during repetitive activities.

Our study correlated age with handgrip of subjects aged 19–22. We found a positive correlation between age and HGS in standing position in both males and females. The presence of positive correlation in standing position may explain the cause of highest grip strength value as the young age male subjects accompanied with higher HGS in this position. This finding was supported by Chandrasekaran et al. who stated that grip strength varied from moderate to high with age in both gender. Earlier studies have established that age and gender are the influencing factors of HGS when measured with Jamar dynamometer. These findings could be explained by age dependent increase of HGS in males and females which were strongly associated with changes of muscle mass during their childhood as well as with normal growth, physical fitness and work capacity.

5. Conclusions

Practical implications from this study are that grip hand strength management from different positions assists the patients in restoring maximal function in activities of daily living, vocational skills and avocational interests after injury or surgery or as a consequence of a disease affecting hand and wrist mobility. Based on the findings of this investigation, the HGS is correlated with the body position while using the standard upper extremity position. This study provides useful values for grip strength in different positions. The practical implications of this study suggest that clinicians who work in settings where grip strengths assessment or training should be undertaken while the patient is in supine position can be obtained from side-lying or prone position. Intermaizes to be seen whether positioning a subject in one of these positions (supine, prone or side-lying) is helpful in preventing fatigue and its subsequent injuries, particularly in old age. Grip strength is highest in standing position and reduces significantly while the subject is in prone position.
This is a critical step in the rehabilitation of upper limb musculature. Failure in the consideration of the subject’s posture influencing the HGS may decrease the reliability of handgrip measurement by changing posture. So, the subject’s posture should be determined during pre- and post-handgrip measurement. In clinical setting, the influence of age on handgrip shall be borne in mind when measuring handgrip particularly in standing position.

References
Prevalence of Scoliosis Among Majmaah University Physical Therapy Students-Saudi Arabia

*Mohammad Walaa S. and Elsais Walaa M.

Department of Physical Therapy, Majmaah University, KSA

*Correspondence email: w.mohammad@mu.edu.sa

ABSTRACT

Scoliosis is the deviation in the normal vertical spine. Although there are numerous studies available about treatment approaches for scoliosis and screening schoolchildren, the numbers of studies that screen university student are limited. The present study aimed to investigate the prevalence of scoliosis, and to examine the correlation between scoliosis prevalence and increasing level (year) of study among physical therapy students in Majmaah University, Saudi Arabia. One hundred and fifty-two physical therapy students between 20 and 24 years of age were investigated. Ninety-two of these students were females and 60 were males. Spinal mouse (SM) was used to evaluate the frontal plane curvature of the student's spine. There was a high prevalence of scoliosis (31.5%) among physical therapy students at Majmaah University, particularly among female students, with the female-male ratio of 3:1. There were significant association between the scoliosis prevalence and the level of study in female students. It is obvious that female physical therapy students tend to develop scoliosis more than male students during the different levels of study for physical therapy program.

Keywords: Majmaah University, scoliosis, physical therapy students, spinal-mouse.

INTRODUCTION

Scoliosis refers to a spinal deformity characterized by lateral curvature with rotation of the involved vertebrae around a vertical axis. It is considered as one of the musculoskeletal disorders affecting adolescent, especially girls for unknown cause. It was noticed in Riyadh, the capital of Saudi Arabia, that such pathology occurred in 2.5% of schoolgirl and subsequently impact their daily life. Several risk factors may have a role in changing posture and developing such case. These factors include inherent factors like age, sex and job-related factors. Moreover, physical therapy is a highly physical fitness job-demanding and may require assuming a faulty posture especially when dealing with paediatric and neurologic disorders cases. Therefore, physical therapy practice can lead to work-related musculoskeletal disorders. Consequently, activities related to physical therapy practice may affect posture and alter subjects' balance. Bettany-Saltikov et al. confirmed that carrying the load on the right shoulder significantly increased the thoracic lateral curvature in the frontal plane and decreased the thoracic kyphosis in the sagittal plane, especially a 17% load carrying causes significant changes in spinal alignment.

In the same context physical therapy students are likely at risk of functional scoliosis due to their job characteristics, e.g. lifting and transferring a patient, handling techniques. Such manoeuvres may excessively load the body mechanics and put unnecessary strain on the spine. Therefore, screening could alert students about the possible spinal problem and increase their awareness about the postural care. Postural evaluation is an important assessment procedure for clinicians. Scoliosis screening is considered as a part of the primary care management of adolescent health. This primary care is very important for improving the quality of university life. Screening programs can identify most cases of previously undiagnosed orthopaedic abnormalities, improve our knowledge of the prevalence and pattern of musculoskeletal disorders, especially scoliosis, with early diagnosis can alter the natural progression of the disease. Previous studies have focused on risk factors or prevalence of scoliosis in schoolchildren or the pattern of scoliosis in spinal unit in Saudi Arabia. Other research studied the work-related musculoskeletal...
disorders in physical therapists.\textsuperscript{[7,14]} Little data is known about the prevalent rates of scoliosis in physical therapy students in Saudi Arabia.

So, purposes of our study were (i) to investigate the prevalence and classify types of scoliosis among physical therapy students in Majmaah University, KSA (ii), to determine the correlation between scoliosis prevalence and the level (year) of study. We hypothesized that, the prevalence of scoliosis in female students might be more than in males, and a positive correlation might be present between the scoliosis prevalence and level (year) of study.

**MATERIALS AND METHODS**

**Design**
A cross-sectional study was conducted to assess the prevalence of scoliosis among physical therapy students, and to test the relationship between scoliosis prevalence and the level (year) of study at Majmaah University.

**Sample Characteristics**
We assessed hundred and fifty-two physical therapy students aged between 20 and 24 years old. Ninety-two of students were females and 60 were males. The students examined were at study level from level 4 to level 8, in addition to internship students. The number of subjects was determined a priori based on statistical power analysis to ensure type I error did not exceed 0.05 and type II error did not exceed 0.20. This analysis indicated that 132 subjects were required to find a power of 96% and level of significance of 95%. Exclusion criteria included a student who had spine related accidents or has been treated with spinal operation or those with permanently limited mobility of the spine. The study was applied in Department of Physical Therapy, Faculty of Applied Medical Sciences, Majmaah University, Saudi Arabia. Ethical approval was obtained before the commencement of the study, and consent was obtained from each participant.

**Measuring devices**
The frontal plane curvature of the student was evaluated by spinal mouse (SM) (Fig. 1). The device provides data to the computer with Bluetooth and the measured curvatures are shown on the computer display. The method has no medical risk or danger. The device has two rolling wheels follow the spinous processes of the spine, and distance and angle measures are transferred from the device to a personal computer. Data are sampled every 1.3 mm as the mouse is rolled along the spine, giving a sampling frequency of approximately 150 Hz. This information is then used to calculate the relative positions of the each vertebra, angles between the vertebrae and total angle of frontal and sagittal plane curvatures with using its own software. Spinal Mouse is a validated and reliable tool for measuring spinal curvatures in the frontal and sagittal planes.\textsuperscript{[15-17]} The software is characterized by absence of X-ray, small dimension, ergonomic design and compatible Microsoft Office for the execution of the recording.

The measurements were made in a quiet and well-lit environment where there was nothing to distract the subject or the examiner. The students were asked to stand symmetrically, dividing their weight equally between the two feet as much as possible. The position was first described, demonstrated and practiced by the examiner for each student before the measurement. The C7–S3 vertebral spinal processes were determined and marked with a marker while the student was standing up straight in the anatomical position. The SM was then moved downwards over the spinal criteria points. The measurements were made early in the day to prevent positional differences of the patient due to fatigue, stress, psychological factors, etc.

**Statistical analysis:**
The data transferred to the computer through the SM are analyzed and the angular deviation between each vertebral segment pair is provided as an angle. The prevalence of scoliosis among physical therapy students was analyzed using the Statistical Package for Social Sciences (version 20.0 for Windows; SPSS Inc., Chicago, IL). The level of significance was set at $P < 0.05$ for all statistical tests. A Chi-square test was used to determine the relationship between scoliosis prevalence and increasing the study level.

**RESULTS**
A total of 152 (92 females, 60 males) physical therapy students were included in the study (Table 1). Forty-eight of the participants had scoliotic deformity (31.5%), 36 of them were females and 12 were males, with female-male ratio of 3:1. The prevalence of scoliosis was substantially high among female students (39%), while it was 20% among male students. The highest curvature deformity was thoracolumbar in 101 students (66.4%), thoracic in 34 students (22.4%) and lumbar in 17 students (11.2). There were 77.6% right sided curve and 22.4% left sided curve.

With regard to the correlation of scoliosis prevalence and level of study in physical therapy, Chi-square demonstrated a significant association between level of study and the scoliosis prevalence ($p = 0.011$) (Table 2). However, there was no significant association in male students. Results show that, most of the students with scoliosis were in level 6 (third year of study) (Fig. 2,3).
DISCUSSION

This is the first study investigating the prevalence of scoliosis in a population of physical therapy student at Majmaah University. In this study, where physical therapy students were dealing with patients in various settings, we found a high prevalence of scoliosis; particularly in female students. The results of the current study is in agreement with other studies. The prevalence of scoliosis may be due to job-related risks that are relevant to physical therapy. Cromie et al. reported that therapists’ job include activities that contribute to their injury. These activities like lifting or transferring patients who were heavy and dependent on therapists for transfer may load body mechanics and putting their back under strain. In addition, the major contributing factor in the development of their work-related symptoms may be the inadequate training in injury prevention. In this study, the highest prevalence of scoliosis was observed in females confirming the results of studies by Al-Arjani et al., Lee et al., Baroni et al. in which the authors reported female-male ratios of 2:1, 4:5:1 and 3:8:1; respectively. This may be due to the spine of female physical therapist become at high risk when lifting or transferring larger patients. Moreover, this reflects the lack of awareness about back deformity, or being in a conservative community, where the females do not participate in sports. Therefore, they had a high prevalence of work-related musculoskeletal disorder.

The findings of current study indicated that level of study was significantly associated with the scoliosis prevalence in female students. This can be attributed to that the level 6 female students subjected to high stress on their spine. Such level is considered the beginning of clinical practice and dealing with patients. Then, with higher level of study, the females become have a good awareness about the injury prevention. However, the internship demonstrated high percent of scoliosis that may be due to the large number of patients treated or performing more activities that generate high spinal stresses. On the other hand, no association was found in male students, which may contribute to more adaptation to correct posture in routine life. In addition, the results may reflect that male students become more concerned about their health.

Table 1: Demographic and anthropometric characteristics of physical therapy students

<table>
<thead>
<tr>
<th>Groups</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)*</td>
<td>21.25 ± 1.37</td>
<td>21.69 ± 1.24</td>
</tr>
<tr>
<td>Height (cm)*</td>
<td>171.85 ± 7.19</td>
<td>156.65 ± 6.02</td>
</tr>
<tr>
<td>Weight (kg)*</td>
<td>68.22 ± 9.74</td>
<td>52.96 ± 6.83</td>
</tr>
<tr>
<td>BMI (kg/m²)*</td>
<td>22.77 ± 3.17</td>
<td>21.65 ± 3.13</td>
</tr>
</tbody>
</table>

*Values are expressed as mean ± SD.

Table 2: The study level distributions of students with and without scoliosis and association with scoliosis prevalence

<table>
<thead>
<tr>
<th>Variable</th>
<th>Females (n = 92)</th>
<th>Chi-square test (P value)</th>
<th>Males (n = 60)</th>
<th>Chi-square test (P value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of study, n (%)</td>
<td>With scoliosis (n = 36)</td>
<td>Without scoliosis (n = 56)</td>
<td>With spinal deformity (n = 12)</td>
<td>Without spinal deformity (n = 48)</td>
</tr>
<tr>
<td>Level 4</td>
<td>4 (11.1)</td>
<td>4 (7.1)</td>
<td>2 (16.7)</td>
<td>5 (10.4)</td>
</tr>
<tr>
<td>Level 5</td>
<td>4 (11.1)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>4 (8.3)</td>
</tr>
<tr>
<td>Level 6</td>
<td>12 (33.3)</td>
<td>28 (50.0)</td>
<td>4 (33.3)</td>
<td>11 (22.9)</td>
</tr>
<tr>
<td>Level 7</td>
<td>8 (22.2)</td>
<td>8 (14.3)</td>
<td>2 (16.7)</td>
<td>15 (31.3)</td>
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<tr>
<td>Level 8</td>
<td>0 (0)</td>
<td>8 (14.3)</td>
<td>1 (8.3)</td>
<td>9 (18.8)</td>
</tr>
<tr>
<td>Internship</td>
<td>8 (22.2)</td>
<td>8 (14.3)</td>
<td>3 (25)</td>
<td>12 (25)</td>
</tr>
</tbody>
</table>

*Significant, p < 0.05.
†NS: not significant.
CONCLUSION

Female physical therapy students at Majmaah University were found to be a high-risk group for job-related spinal deformity, especially scoliosis (39%). Furthermore, gender, the physical demands of physical therapy practice and inadequate training in injury prevention were found to be risk factors for occupational spinal deformity (scoliosis). Therefore, training program should be admitted to physical therapy students before the beginning of clinical practice aiming to decrease the spinal stresses and back deformities.

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