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ROLE OF SPINAL MOBILITY ON UNSUPPORTED UPPER EXTREMITY EXERCISE CAPACITY IN ASYMPTOMATIC YOUNG ADULTS: A CROSS-SECTIONAL STUDY

ORIGINAL ARTICLE

ABSTRACT

Purpose: Upper extremities are essential to perform activities of daily living. Along with many factors, the spinal region has an important effect on performing upper extremity movements. Our study's first aim was to examine the relationship between unsupported upper extremity exercise capacity (UUEEC) and spinal mobility. The second aim of the study was to determine whether spinal mobility is a predictor of the UUEEC.

Methods: Forty asymptomatic and volunteer individuals (age=21.50±1.51 years, 52.5% of females) were included in the study. The 6-minute pegboard and ring test (6PBRT) was performed to assess the UUEEC. Spinal mobility was assessed to use a hand-held, computer-assisted electromechanical device (the Spinal Mouse System, Idiag, Fehraltorf, Switzerland). The spinal mobility analysis in the sagittal (SAP – maximal extension/flexion) and the coronal (CRP – maximal left/right lateral flexion) plane was measured.

Results: The 6PBRT score had a moderate and positive correlation with the SAP spinal mobility (r=0.361, p=0.022) and the CRP spinal mobility (r=0.322, p=0.043). Stepwise multiple linear regression analysis demonstrated that the SAP spinal mobility was a significant and independent predictor of the 6PBRT score with 11% of the variance.

Conclusions: The SAP spinal mobility was found as a predictor of the UUEEC in asymptomatic individuals. This study demonstrates that UUEEC could be improved by increasing spinal mobility.

Key Words: Exercise Test; Spine; Upper extremity.

ASEMPTOMATİK GENÇ ERİŞKİNLERDE DESTEKSİZ ÜST EKSTREMİTE EGZERSİZ KAPASİTESİ ÜZERİNDE SPİNAL MOBİLİTENİN ROLÜ: KESİTSEL BİR ÇALIŞMA

ARAŞTIRMA MAKALESİ

ÖZ

Amaç: Üst ekstremiteler günlük yaşam aktivitelerini gerçekleştirmek için önemlidir. Omurga bölgesi birçok faktörle birlikte üst ekstremite hareketlerinin gerçekleştirilmesinde önemli bir etkiye sahiptir. Çalışmamızın ilk amacı DÜEEK ile spinal mobilite arasındaki ilişkiyi incelemekti. Çalışmanın ikinci amacı, spinal mobilitenin DÜEEK'in bir belirleyicisi olup olmadığını belirlemekti.

Yöntem: Çalışmaya kırk asemptomatik ve gönüllü birey (yaş=21,50±1,51 yıl, 52,5% kadın) dahil edildi. DÜEEK'ni değerlendirmek için 6-dakika pegboard ve ring testi (6PBRT) yapıldı. Spinal mobilite elde taşınabilen, bilgisayar destekli bir elektromekanik cihaz (Spinal Mouse System, Idiag, Fehraltorf, İsviçre) kullanılarak değerlendirildi. Sagittal (SAD- maksimal ekstansiyon/fleksiyon) ve koronal (KRD-maksimal sol/sağ lateral fleksiyon) düzlemde spinal mobilite ölçüldü.

Sonuçlar: 6PBRT skoru ile SAD spinal mobilite (r=0,361, p=0,022) ve KRD spinal mobilite (r=0,322, p=0,043) arasında orta güçte ve pozitif bir ilişki vardı. Kademeli çoklu doğrusal regresyon analizi SAD spinal mobilitenin 6PBRT skorunun % 11 varyans ile anlamlı ve bağımsız belirleyicisi olduğunu gösterdi.

Tartışma: SAD spinal mobilite, asemptomatik bireylerde DÜEEK'nin bir belirleyicisi olarak bulundu. Bu çalışma DÜEEK'nin spinal mobilite artırılarak geliştirilebileceğini göstermektedir.

Anahtar Kelimeler: Egzersiz Testi; Omurga; Üst ekstremite.

INTRODUCTION

Upper extremities are essential to perform a lot of different tasks (1). These tasks' most important ones are daily living activities such as drinking, eating, dressing, personal hygiene, and work-related tasks. Additionally, unsupported upper limb movement is required to perform many of these activities (2). At the same time, upper extremity activities play a significant role in many sports (3,4). It has been shown that some of the muscles that participate in upper extremity positioning may have both ventilatory and postural tasks (5). As a result, when the upper extremity elevates, oxygen consumption increases by approximately 16%, and pulmonary ventilation, increasing by about 24% in healthy individuals (5). This situation limits people in performing and maintaining upper limb movements. Unsupported upper extremity exercise capacity (UUEEC) is limited in healthy individuals and patients with cardiopulmonary disease (5,6). Therefore, it is vital to know the predictors of the UUEEC.

Along with many factors, the spinal region has an essential effect on performing upper extremity movements. However, functional upper extremity movement is the capacity of a physiological synergy of separate body parts (pelvis, spine, and shoulder) as a segment of a kinetic chain (7). It has been demonstrated that the lower body and the trunk have a vital role in physical performance, contributing to approximately 55% of the total force and kinetic energy generated during a throw (8), around 80% of the total available range of "trunk" axial rotation, (9) and kinematically crucial to the upper extremity (10,11). Additionally, it has been shown that three times higher elbow/shoulder injury prevalence occurs with low trunk rotation flexibility in softball players (12). Besides, the activation of the muscles of both regions is interrelated. Clark et al. have demonstrated that lumbar multifidus activation is associated with anterior deltoid activation (13).

Although the relationship between upper extremity movements and spinal region is known, the relationship between the UUEEC and spinal mobility has not been studied to the best of our knowledge. Additionally, knowing the possible predictors of the UUEEC would contribute to developing the activities of daily living and other activities related to the upper extremity. Therefore, the first aim of our study was to examine the relationship between UUEEC and spinal mobility. The second aim of the study was to determine whether spinal mobility is a predictor of the UUEEC.

METHODS

Asymptomatic and volunteer young adults without any deformity or pathology of the spine in the age range of 18 to 25 years were included in this cross-sectional study. Persons with a diagnosed disease (orthopeadic, cardiopulmonary, or neurologic disease) and a pathology involving upper and lower extremities were excluded from the study (14). The study was announced to participants via social media and brochure. The study was performed at Kırşehir Ahi Evran University, School of Physical Therapy and Rehabilitation, between November 2019 and March 2020. The Kırşehir Ahi Evran University Ethics Committee approved the study protocol (Approval Date: 08.10.2019 and Approval number: 2019-17/175). All the participants provided written, informed consent to participate in the study. The study was conducted following the Declaration of Helsinki standards.

The socio-demographic characteristics of the participants were recorded. The exercise and smoking habits of the participants were questioned.

The 6PBRT was performed to assess the UUEEC. The test was performed following the method described by Zhan et al. (15). Four pegs (two pegs were positioned at the shoulder level and two other pegs at 20 cm above the shoulder level) and a total of 20 rings (ten rings for each of the two lower pegs) are placed on a pegboard in this test. Participants were asked to sit straight in a chair. A pegboard was placed in front of the participants at arm's length from the body. Participants were asked to use both hands simultaneously to move one ring from each of the lower pegs to the upper pegs, then vice versa. The total number of rings placed was calculated at the end of six minutes. Hemodynamic responses, dyspnea, and fatigue were assessed before and after the 6PBRT.

Spinal mobility was assessed to use a hand-held, computer-assisted electromechanical device (the Spinal Mouse System, Idiag, Fehraltorf, Switzerland). Pivot points were determined as the spinous process of C7 and the top of the anal crease (approximately S3). Measurements were performed between these two points. Measurements were made in the maximal flexion/extension and maximal left/right lateral flexion positions. The analysis of spinal mobility in the sagittal (SAP – maximal extension to flexion) and the coronal (CRP – maximal left to right flexion) plane was assessed (16).

A previous study showed a significant association between upper extremity muscle strength and core endurance (17). Based on the study, the minimum required sample size was calculated as 40 participants for the probability level as 0.05, the anticipated effect size as 0.41, and the statistical power level as 80% using 'Correlation: Point-Biserial Correlation Statistical Test' in G*Power Software (Version 3.1.9.2, Düsseldorf University, Düsseldorf, Germany).

Statistical Analysis

The data was analyzed to use the IBM SPSS Statistics for Windows software (Version 20.0., IBM Corp., Armonk, New York, USA). The Shapiro–Wilk test and histograms were used to check normality. Values are expressed as mean ± standard deviation or median (25-75 quartiles) for continuous variables, and frequencies were reported for categorical variables. The paired sample t-test and the Wilcoxon test were used to compare before and after the 6PBRT parameters. The Pearson product-moment correlation coefficients were used to examine the correlations between the 6PBRT score and spinal mobility. Correlation coefficients of >0.50 were considered a strong correlation, 0.30–0.50 as a moderate correlation, and 0.20–0.30 as a weak correlation (18). The stepwise multiple linear regression analysis was used to identify predictors of the 6PBRT score. The level of significance was set at $p<0.05$ (19).

RESULTS

Initially, we had taken 44 participants; but four of the participants were excluded from the study due to not completing the tests. The data obtained from 40 participants (52.5% of females) were analyzed. The characteristics of the participants are presented in Table 1.

Heart rate, systolic blood pressure, diastolic blood pressure, and fatigue values were higher after the test than before the 6PBRT (Table 2).

Table 1: Participants' Characteristics.

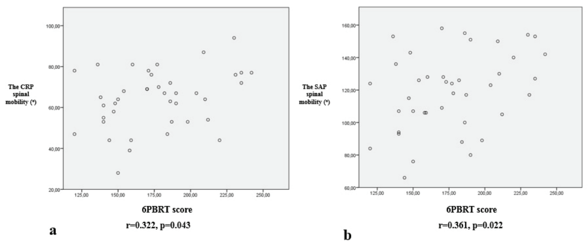
Variables	**Subjects (n=40)**	
Characteristics	**Mean ± SD**	**Min-Max**
Age (years)	21.50±1.51	18-25
Sex (female, %)	21	52.50
Weight (kg)	68.50±12.69	47-93
Height (cm)	171.45±10.37	150-193
BMI (kg/m²)	23.19±3.24	16.90-35.44
Exercise Habit (yes), n (%)	19	47.50
Smoking Habit (yes), n (%)	13	32.50
Smoking history (pack-years)	1.60±2.67	0.00-10.00
Spinal Mobility Parameters		
Total Spinal extension (°)	24.25±11.28	2-49
Total Spinal flexion (°)	95.07±16.92	50-130
The SAP Spinal Mobility (°)	119.32±24.06	66-158
Total Spinal Left Lateral Flexion (°)	32.55±6.31	20-47
Total Spinal Right Lateral Flexion (°)	31.62±8.80	8-50
The CRP Spinal Mobility (°)	64.17±14.20	28.94

BMI: body mass index, SAP: sagittal plane, CRP: coronal plane.

Table 2: The 6-Minute Pegboard and Ring Test Parameters.

6-Minute Pegboard and Ring Test	Subjects (n=40)		p
	Baseline	After	
	Mean±SD	Mean±SD	
Heart Rate (bpm)	85.28±11.91	91.30±12.44	**<0.001[a*]**
SpO_2 (%)	97.52±1.13	97.10±1.39	0.074[a]
SBP (mmHg)	111.50±12.51	118.63±16.90	**<0.001[a*]**
DBP (mmHg)	69.00±8.71	72.75±9.12	**0.006[a*]**
Dyspnea (MBS)[ϕ]	0 (0-0)	0.0 (0.0-0.0)	0.102[b]
Arm Fatigue (MBS) [ϕ]	0.0 (0.0-3.0)	4.0 (2.25-5.0)	**<0.001[b*]**
General Fatigue (MBS) [ϕ]	0.0 (0.0-3.0)	2.0 (0.0-4.0)	**<0.001[b*]**
6PBRT score	176.85±33.38		120-242[§]

*p<0.05. [a]paired sample t-test, [b]Wilcoxon signed rank test. [ϕ]Median (Inter quartile range). [§]Min-Max. SBP: systolic blood pressure, DBP: diastolic blood pressure, MBS: Modified Borg Scale, 6PBRT: 6-Minute Pegboard and Ring Test.



The 6PBRT score had moderate and positive correlation with the SAP spinal mobility (r=0.361, p=0.022) and the CRP spinal mobility (r=0.322, p=0.043) (Table 3, Figure 1).

The SAP spinal mobility and the CRP spinal mobility were included as independent variables in the regression model to determine the possible predictors of the 6PBRT score. Stepwise multiple linear regression analysis demonstrated that the SAP spinal mobility was significant and independent determinant of the 6PBRT score with 11% of the variance (Table 4 and Figure 2).

The regression equation formula of the dependent variable was calculated by using explanatory variables and coefficients. The regression equation formula is:

"6PBRT score = 117.09 + (SAP spinal mobility x 0.50)."

DISCUSSION

The study's main finding demonstrated that SAP spinal mobility was founded as a predictor of the UUEEC in asymptomatic individuals. Besides, this study showed that the UUEEC had a moderate and positive correlation with the SAP spinal mobility and the CRP spinal mobility.

The 6PBRT was performed to assess the UUEEC in this study (15). The mean 6PBRT score was 176.85±33.38. There are no reference values for the 6PBRT in healthy adults in Turkey, making comparisons more difficult. A previous study conducted in Brazil stated that the average of the 6PBRT scores between different age groups (over 30 years old) ranged between 215 and 132 (20). According to these values, it could be said that 6PBRT scores are lower than the previous study, considering our age group. Hemodynamic responses, dyspnea, and fatigue were assessed before and after the 6PBRT. If more than 120 bpm of the resting heart rate, systolic blood pressure is more significant than 180 mmHg or diastolic blood pressure greater than 100 mmHg and SpO2 <80% before testing were not applied to the participants (21-23). Additionally, heart rate, systolic blood pressure, diastolic blood pressure, and fatigue values were higher after the

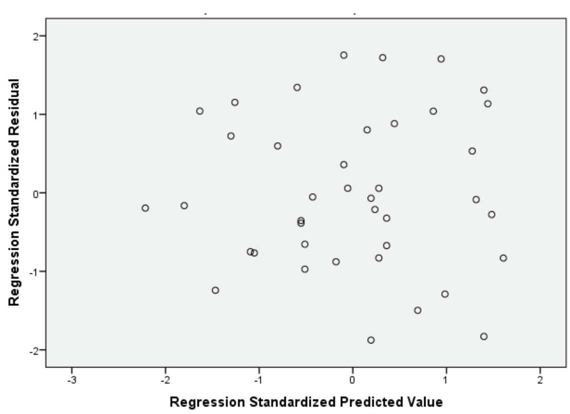


Table 3: Correlation between the 6-Minute Pegboard and Ring Test Score and Spinal Mobility

Parameters	r	p
The SAP Spinal Mobility (°)	0.361	**0.022***
The CRP Spinal Mobility (°)	0.322	**0.043***

*p<0.05. r: Pearson product moment correlation coefficient. SAP: sagittal plane, CRP: coronal plane.

Table 4: Stepwise Multiple Linear Regression Model of the 6-Minute Pegboard and Ring Test.

Variable	B	SE	Beta	t	VIF	P
Constant	117.09	25.52	-	4.58	-	**<0.001***
The SAP spinal mobility (°)	0.50	0.21	0.36	2.38	1.000	**0.022***

*p<0.05. r=0.36; R^2=0.13; adjusted R^2=0.11 (F=5.696). B: unstandardized regression coefficient, SE: standard error, VIF: variance inflation factors SAP: sagittal plane

test than before the 6PBRT. Studies investigating 6PBRT, including wide age ranges in the Turkish population, are needed.

Studies investigating the effects of smoking on spinal mobility are quite limited. Dishauzi et al. have demonstrated that the non-smoking participants demonstrate higher spinal mobility than the smoking group (24). Additionally, exercise habits could affect spinal mobility (25). The study participants' percentages of smoking and exercise habits were 32.5% and 47.50%, respectively. In this respect, studies evaluating spinal mobility separately according to smoking and exercise habits are needed.

Upper extremities play an essential role in a lot of different tasks (1). Many of these tasks occur with unsupported upper extremity movements (2). Therefore, factors affecting upper extremity functions should be well known (26). Many body regions such as the spine, pelvis, and shoulder work in a certain synergy in performing functional upper limb movements. The spinal region has an essential effect on performing upper extremity movements in this synergy (7). Crosbie et al. have demonstrated that humeral, scapular and thoracic segments demonstrate consistent, synchronous interactions (27). Heneghan et al. have demonstrated that thoracic spine mobility is an essential link in upper limb kinetic chains (7). Besides, it has been demonstrated that lumbar multifidus activation is associated with anterior deltoid activation (13). Although the spinal region's effects on upper extremity movements are known, the relationship between the UUEEC and spinal mobility has not been studied, making comparisons more difficult. In addition to the literature, we found that the UUEEC had a significant correlation with spinal mobility. These results show that planned methods to increase spinal mobility may contribute to improving the UUEEC. In cases where spinal mobility is reduced, dysfunction may occur in the upper extremity. Especially in diseases and problems affecting spinal mobility and posture, examining this issue would be guiding.

The SAP spinal mobility was founded as a predictor of the UUEEC with 11% variance in our study. A previous study showed a strong relationship between the range of arm elevation and the SAP mobility (range of thoracic extension) (28). This study may explain that SAP is a predictor of UUEEC, but high-quality research and examination are needed in this area. Although the SAP spinal mobility was founded as a predictor of the UUEEC, the 11% variance value is not very high. Many factors, such as upper extremity muscle strength, coordination, agility, anthropometric features, handgrip strength, and psychological factors, could affect the UUEEC. More comprehensive studies to be carried out in the future would guide in this area.

This study had some limitations. First, in our study, we did not discriminate participants against gender. Physical differences between genders may affect results. Second, the cross-sectional design of the study precludes inferences about the direction of causality among the variables. Third, in our study, we only evaluated asymptomatic young adults. In this respect, these results may vary in different disease groups.

In conclusion, the SAP spinal mobility was a predictor of the UUEEC in asymptomatic young adults in this first study in the literature investigating the relationship between spinal mobility and the UUEEC. This study suggests that UUEEC could be improved by increasing spinal mobility.

Sources of Support: None.

Conflict of Interest: The authors report no conflict of interest.

Ethical Approval: This study protocol was approved by the Kırşehir Ahi Evran University Ethics Committee (Approval Date: 08.10.2019 and Approval Number: 2019-17/175)

Informed Consent: A written informed consent was obtained from each subject.

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