Core Muscle Endurance, Upper Extremity Muscle Strength, Grip Strength, and Hand-Eye Coordination in Young Adults with Generalized Joint Hypermobility*

Deniz TUNCER**, Sude İRDEM***, Emir YILMAZ*****

Abstract

Aim: Generalized joint hypermobility (GJH) is recognized as one of the risk factors for musculoskeletal impairments. This study aimed to evaluate core muscle endurance, upper extremity muscle strength, grip strength, and hand-eye coordination in young adults with GJH.

Method: This is a cross-sectional and observational study. Twenty-seven young adults with GJH, aged 17–26 years, and an age-matched group of 27 young adults without GJH were recruited in the study. All participants performed core muscle endurance tests, upper extremity muscle strength test, hand-grip and pinch-grip strength tests, and the alternate hand-wall toss test.

Results: Considering the descriptive features, no statistically significant differences were identified between the groups ($p>0.05$). The mean Beighton score was 5.26±2.38 in the GJH group, which indicates joint hypermobility ($p<0.001$). While a significant difference was found between the groups for the trunk flexion test ($p = 0.002$), right side plank test ($p=0.013$), and left side plank test ($p=0.039$) in the tests of core muscle endurance, there was no significant difference in the trunk extension test ($p=0.532$), horizontal plank test ($p=0.190$), and alternate hand wall toss test ($p=0.127$).

Conclusion: The young adults in the present study who had been grouped as having GJH (Beighton score≥4) showed a decline in upper extremity strength, grip strength, and core muscle endurance. This study, in combination with the findings of the literature, suggests that a comprehensive screening program for the early recognition of GJH is required to prevent musculoskeletal problems.

Keywords: Coordination, hypermobility, muscle strength, young adult.

Generalize Eklem Hipermobilitesi Olan Genç Erişkinlerde Core Kas Dayanıklılığı, Üst Ekstremite Kas Kuvveti, Kavrama Kuvveti ve El-Göz Koordinasyonu

Öz

Amaç: Generalize eklem hipermobilitesi (GEH) kas-iskelet sistemi bozuklukları için risk faktörlerinden biri olarak kabul edilmektedir. Bu çalışmada GEH'li genç erişkinlerde core kas dayanıklılığı, üst ekstremite kas kuvveti, kavrama kuvveti ve el-göz koordinasyonunun değerlendirilmesi amaçlandı.

Yöntem: Bu kesitsel ve gözlemsel bir çalışmadır. Çalışmada yaşları 17-26 arasında değişen GEH'li 27 genç erişkin grup ve GEH olmayan 27 genç erişkin grup karşılaştırıldı. Tüm katılımcılara core kas dayanıklılık

Özgün Araştırma Makalesi (Original Research Article)
Geliş / Received: 03.04.2024 & **Kabul / Accepted:** 11.11.2024
DOI: https://doi.org/10.38079/igusabder.1463020
* This research was granted by the 2209-A TUBITAK (The Scientific and Technological Research Council of Türkiye) for the financial support of a student research project numbered with 1919B012216285 ; This research was previously presented as an oral presentation at the 9th National Physiotherapy and Rehabilitation Congress.
*** (Corresponding author) Asst. Prof., PhD PT., Bezmialem Vakif University, Faculty of Health Sciences, Division of Physiotherapy and Rehabilitation, Istanbul, Türkiye. E-mail: dtuncer@bezmialem.edu.tr
ORCID https://orcid.org/0000-0003-4975-827X
**** PT., Retafiz Physical Therapy and Rehabilitation Center, Istanbul, Türkiye. E-mail: sudeirdem8@gmail.com
ORCID https://orcid.org/0009-0002-3376-689X
***** PT., Ahikent Hasbahce Special Education and Rehabilitation Center, Istanbul, Türkiye.
E-mail: emirylmaz6134@gmail.com ORCID https://orcid.org/0009-0002-9252-5105

ETHICAL STATEMENT: The Bezmialem Vakif University Non-interventional Clinical Research Ethics Committee (date-number: 17.04.2023-104359) approved this cross-sectional and observational study. The study was registered on the ClinicalTrials.gov website (registration number: NCT05896722), and the protocol followed the of the Declaration of Helsinki guidelines.

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

testleri, üst ekstremite kas kuvveti testi, el kavrama ve parmak kavrama kuvveti testleri ve alternatif el-duvar fırlatma testi uygulandı

Bulgular: Tanımlayıcı özellikler göz önüne alındığında, gruplar arasında istatistiksel olarak anlamlı bir fark tespit edilmedi (p>0,05). Ortalama Beighton skoru GEH grubunda 5,26±2,38 olup eklem hipermobilitesini göstermektedir (p<0,001). Core kas enduransı testlerinde gövde fleksiyon testi (p=0,002), sağ yan köprü testi (p=0,013) ve sol yan köprü testi (p=0,039) için gruplar arasında anlamlı fark bulunurken, gövde ekstansiyon testi (p=0,532), horizantal köprü testi (p=0,190) ve alternatif el duvar fırlatma testinde (p=0,127) anlamlı fark bulunmadı.

Sonuç: Bu çalışmada GEH tespit edilen (Beighton skoru≥4) genç erişkinlerin üst ekstremite ve kavrama kuvveti ile core kas dayanıklılığında azalma görüldü. Çalışma, literatürdeki bulgularla birlikte, kas-iskelet sistemi sorunlarının önlenmesi için GEH'in erken tespit edilmesine yönelik kapsamlı bir tarama programının gerekli olduğunu düşündürmektedir.

Anahtar Sözcükler: Genç erişkin, hipermobilite, kas kuvveti, koordinasyon.

Introduction

Generalized joint hypermobility (GJH) is known as a clinical disorder with the ligament laxity in which the joints can present too wide-ranging motion, independent of any rheumatic disease[1]. The studies in the literature are mostly focused on benign joint hypermobility syndrome, which is the symptomatic form of GJH. In some studies, the terms GJH and benign joint hypermobility syndrome were considered synonymous. However, GJH is not a diagnosis; it is a condition and does not necessarily cause symptoms[2]. Many people have multiple hypermobile joints, and this condition, known as GJH, is not harmful in some circumstances[3]. Since it is the most universally accepted threshold in adults and correlates with the revised 1998 Brighton criteria, the Beighton score ≥ 4/9 is used to determine those with GJH[4].

Hypermobility has been reported to increase the risk of musculoskeletal problems and injuries to joints such as subluxations, dislocations, and sprains[5-8]. Scheper et al. also noted that more pain, fatigue, and disability are experienced in people with GJH[9]. Considering all these risks, decreased muscle endurance and strength could contribute to the higher risk of injuries in people with GJH.

Hand-eye coordination is the ability to do activities through simultaneous use of hands and eyes for completing motor tasks, as properly determined by the movement control processes[10]. Upper limb muscle strength contributes to being able to perform strong movements with hands.

To date, there is no known study evaluating core muscle endurance, upper extremity muscle strength, grip strength, and hand-eye coordination in young adults with GJH. Hence, the hypotheses of this study were as follows:

H_1: Core muscle endurance is weaker in young adults with GJH than in their non-GJH peers.

H_2: Upper extremity muscle strength is weaker in young adults with GJH than in their non-GJH peers.

H_3: Grip strength is weaker in young adults with GJH than in their non-GJH peers.

H_4: Hand-eye coordination is weaker in young adults with GJH than in their non-GJH peers.

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

Material and Methods

Study design

The Bezmialem Vakif University Non-interventional Clinical Research Ethics Committee (date - number: 17.04.2023-104359) approved this cross-sectional and observational study. The study was registered on the ClinicalTrials.gov website (registration number: NCT05896722), and the protocol followed the Declaration of Helsinki guidelines.

Sample size

The sample size was calculated by the G-Power 3.1 (Universitat Kiel, Germany)[11]. Based on the upper extremity muscle strength data measured in a study by Jindal et al.[12], while α=0.05 and the power of the test was 80%, the sample size was determined as 27 for each group (d=0.69, α=0.05).

Participants

Twenty-seven young adults (9 male, 18 female) with GJH aged 17-26 years and an age-matched group of 27 young adults (13 male, 14 female) without GJH were recruited in the study.

A score of ≥ 4/9 on the Beighton score and being between the ages of 17 and 26 were required for the GJH group to be included. The exclusion criteria were the existence of benign joint hypermobility syndrome, any neurological, rheumatic, musculoskeletal, and connective tissue disease, cognitive, mental, and/or serious psychiatric illness, a history of fracture or surgery in the upper extremity, pain, deformity, or surgical history related to the vertebral column and upper extremity, and participating in any exercise program or sporting activity in the last six months. A score of <4/9 on the Beighton score and being between the ages of 17 and 26 were required for the non-GJH group to be included. Similar exclusion criteria were accepted for the non-GJH group. An informed consent form was signed by each participant.

Study procedures

All testing procedures were carried out at Bezmialem University, Faculty of Health Sciences, Department of Physiotherapy, and Rehabilitation. Demographic and clinical information were recorded for all participants before testing. The tests were performed on the same day with a 15-min interval between tests.

Joint hypermobility was evaluated with the Beighton score, which is based on performing some maneuvers and measurements on the thumb, fifth finger, elbow, and knee joint and placing the palms on the floor with both knees extended. Joints are evaluated symmetrically, and range of motion is measured with a goniometer. Each hypermobile joint is scored as one point, and ≥ 4/9 indicates the presence of GJH[13].

The sit-and-reach test was used in order to test for flexibility. Participants placed their feet against a box set at a height of 23 cm, and were asked to reach forward with their hands as far as possible while keeping their knees straight. The test was performed three times, and the highest value was recorded in cm[14].

Core muscle endurance tests

The McGill endurance tests have shown excellent reliability (ICC = 0.97-0.99)[15].

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

Trunk flexion: The participant's lower extremities were placed as abducted at approximately shoulder width, and the knees were semiflexed in the supine position. The ankles were fixed, and the hands were positioned on the opposite shoulders. The number of curl-ups was recorded[16].

Trunk extension test: The participant was placed with the inguinal region at the edge of the table. The hips and knees were extended, the ankles were fixed, and the arms were positioned next to the body. The test was terminated when the horizontal position couldn't be maintained (maximum 240 seconds)[17].

Side plank test: The participant was placed in a side-lying position with the lower extremities extended and the upper foot placed in front of the lower foot for support. Elevation was performed on the forearm and ankle until the pelvis and trunk became horizontal. The time spent keeping the body in a straight line was recorded in seconds. Measurements were performed bilaterally[17].

***Horizontal plank test*:** The participant was placed in the push-up position with shoulders and elbows in 90° flexion. The time keeping the body on their feet and forearms in a straight line was recorded in seconds.

Upper extremity muscle strength test: Isometric shoulder, elbow, and wrist muscle strength evaluations were performed with a hand-held dynamometer (MicroFET 2 force gauge, Hoggan Health Industries, Utah). The ICC of the MicroFET 2 force gauge ranged from 0.83 to 0.94[18]. The tests were performed in supine, prone, and sitting positions, using the positions required for the muscle testing method described by Lovett, without compensatory movements. The values resulting from isometric contraction were recorded as kilogram force. Measurements were repeated three times for five seconds bilaterally, and the mean value was recorded[19,20].

Hand-grip strength test: Hand-grip strength was evaluated with a hydraulic hand dynamometer (Jamar, Patterson Medical, Warrenville, IL, USA) in the position recommended by the American Association of Hand Therapists. The Jamar hand dynamometer was found to be highly reliable (ICC = 0.98) and valid (ICC = 0.99) for measuring hand grip strength[21]. The participant was seated in a chair with back support and no armrests, with the elbow flexed at 90° and the forearm in a neutral position, and was asked to squeeze with maximum force. Measurements were performed bilaterally three times and recorded as kilogram force[22].

Pinch-grip strength test: Pinch-grip strength was evaluated with a hydraulic pinch meter (Jamar, Patterson Medical, Warrenville, IL, USA). The ICC of the pinch gauge ranged from 0.95 to 0.99[23]. The participant was placed with the elbow in 90° flexion and the forearm in a neutral position in the sitting position and was asked to squeeze the pinch meter with maximum force in the lateral, palmar, and pinch-grip positions. Measurements were performed bilaterally three times and recorded as kilogram force[24].

Alternate hand-wall toss test: Alternate hand wall indicated a high degree of construct validity for the test (ICC = 0.85)[25]. The participant stood behind a line 2 meters away from the wall. The test started with throwing a tennis ball to the wall with one hand and trying to be caught with the opposite hand to measure hand-eye coordination. The

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

test continued in this way for 30 seconds, and the number of balls caught was recorded[26,27].

Statistical analysis

The data were analyzed using the SPSS Statistics for Windows version 20.0 (SPSS, Inc., Chicago, IL, United States). Data were expressed as the mean ± standard deviation. Analyzing the data for normal distribution was assessed with histograms, probability plots, and the Kolmogorov-Smirnov/Shapiro-Wilk test. Depending on the data's distribution characteristics, the groups were compared using either the Mann-Whitney U test or the Independent Samples T test. Statistical significance was calculated at the $p<0.05$ level.

Results

The descriptive characteristics did not reveal any statistically significant differences between the groups ($p > 0.05$) (Table 1).

Table 1. Comparison of the descriptive characteristics of the groups.

Variables	**GJH group**	**Non-GJH group**	**p value**
	n = 27	**n = 27**	
	m ± SD	**m ± SD**	
Age (years)	21.22 ± 1.62	21.89 ± 1.70	0.146
Height (cm)	170.01 ± 0.11	172.07 ± 0.09	0.531
Weight (kg)	63.70 ± 13.77	67.37 ± 9.77	0.214
BMI (kg/m²)	21.66 ± 3.22	22.59 ± 2.63	0.250
Sex n (%)			
Male	9 (33.3)	13 (48.1)	0.406
Female	18 (66.7)	14 (51.9)	
Dominance n (%)			
Right	21 (77.8)	22 (81.5)	0.500
Left	6 (22.2)	5 (18.5)	

GJH: Generalized joint hypermobility, BMI: Body mass index. Data are reported as n (%) and mean ± standard deviation.

The mean Beighton score was 5.26±2.38 in the GJH group, indicating joint hypermobility ($p<0.001$). While a significant difference was found between the groups for the trunk flexion test ($p = 0.002$), right-side plank test ($p = 0.013$), and left-side plank test ($p = 0.039$) in the core muscle endurance tests, there was no significant difference in the trunk extension test ($p = 0.532$), the horizontal plank test ($p = 0.190$), and the alternate hand wall toss test ($p = 0.127$) (Table 2).

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

Table 2. Comparison of Beighton, sit and reach, alternate hand wall toss test and core muscle endurance test scores of the groups.

	GJH group n = 27 m ± SD	**Non-GJH group n = 27 m ± SD**	**p value**
Beighton score (n)	5.26 ± 2.38	1.19 ± 1.18	**<0.001**
Sit and reach test (cm)	30.52 ± 7.26	28.23 ± 6.18	0.217
AHWTT (n)	13.85 ± 4.93	16.11 ± 5.75	0.127
Core endurance tests			
Trunk flexion (n)	20.89 ± 6.05	26.18 ± 6.04	**0.002**
Trunk extension (sec)	133.93 ± 49.08	142.04 ± 45.57	0.532
Side plank (right) (sec)	34.11 ± 17.87	47.37 ± 19.85	**0.013**
Side plank (left) (sec)	33.74 ± 16.92	44.30 ± 19.59	**0.039**
Horizantal plank (sec)	58.15 ± 33.19	71.37 ± 39.74	0.190

AHWTT: Alternate hand wall toss test, GJH: Generalized joint hypermobility. Data are reported as mean ± standard deviation. Significance at p < 0.05.

A significant difference was found between the groups for elbow flexion strength (non-dominant) (p = 0.012), wrist extension strength (non-dominant) (p = 0.042), hand-grip strength (dominant) (p = 0.032), lateral pinch-grip strength (dominant) (p = 0.027), three-point pinch-grip strength (dominant) (p = 0.026), and three-point pinch-grip strength (non-dominant) (p = 0.001) tests (Table 3).

Table 3. Comparison of upper extremity muscle strength scores of the groups.

	GJH group n = 27 m ± SD	**Non-GJH group n = 27 m ± SD**	**p value**
Upper extremity muscle strength (kgf)			
Shoulder flexion (Dominant)	8.24 ± 1.73	9.04 ± 1.85	0.107
Shoulder flexion (Non-dominant)	8.42 ± 2.99	9.59 ± 2.89	0.148
Shoulder extension (Dominant)	7.58 ± 2.89	8.27 ± 2.34	0.269
Shoulder extension (Non-dominant)	7.91 ± 2.68	8.64 ± 2.46	0.301
Shoulder abduction (Dominant)	11.59 ± 4.92	13.30 ± 5.25	0.224
Shoulder abduction (Non-dominant)	11.06 ± 4.74	13.20 ± 5.51	0.131
Elbow flexion (Dominant)	13.09 ± 2.69	14.33 ± 2.96	0.114
Elbow flexion (Non-dominant)	12.59 ± 3.23	14.95 ± 3.41	**0.023**
Elbow extension (Dominant)	10.53 ± 3.67	11.87 ± 4.05	0.208
Elbow extension (Non-dominant)	10.85 ± 3.87	12.27 ± 4.38	0.212
Elbow supination (Dominant)	6.87 ± 2.41	8.05 ± 2.58	0.089
Elbow supination (Non-dominant)	7.13 ± 2.95	8.22 ± 2.86	0.175
Elbow pronation (Dominant)	8.14 ± 2.91	9.08 ± 2.70	0.225
Elbow pronation (Non-dominant)	7.66 ± 3.02	8.72 ± 2.83	0.189

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

Wrist flexion (Dominant)	9.78 ± 3.02	11.06 ± 3.95	0.186
Wrist flexion (Non-dominant)	9.25 ± 2.97	11.05 ± 3.97	0.065
Wrist extension (Dominant)	9.85 ± 3.79	11.50 ± 4.11	0.132
Wrist extension (Non-dominant)	8.71 ± 2.50	10.48 ± 3.64	**0.039**
Hand-grip strength (kgf)			
Hand-grip strength (Dominant)	22.23 ± 9.74	28.82 ± 11.60	**0.028**
Hand-grip strength (Nondominant)	22.47 ± 11.67	27.18 ± 11.44	0.161
Pinch-strength (kgf)			
Lateral pinch (Dominant)	6.98 ± 2.01	8.20 ± 1.95	**0.017**
Lateral pinch (Non-dominant)	7.03 ± 2.88	8.47 ± 2.38	0.064
Three-point pinch (Dominant)	6.30 ± 1.65	7.34 ± 1.68	**0.026**
Three-point pinch (Non-dominant)	5.67 ± 1.68	7.32 ± 1.86	**0.001**
Two-point pinch (Dominant)	4.39 ± 1.03	4.86 ± 1.29	0.146
Two-point pinch (Non-dominant)	4.04 ± 1.07	4.77 ± 1.66	0.060

GJH: Generalized joint hypermobility. kgf: kilogram-force. Data are reported as mean ± standard deviation. Significance at p < 0.05.

Discussion

Most research in the literature has focused on muscle strength for individuals with GJH, and no studies have been examining core muscle endurance and hand-eye coordination in these people. The present study has revealed more affected strength in the GJH group than the non-GJH group; non-dominant elbow flexion and wrist extension strength, dominant hand-grip, lateral pinch-grip, and three-point pinch-grip strength, and trunk flexion and side plank tests were statistically weaker in the GJH group than the non-GJH group. Alternate hand wall toss test results were similar in groups with GJH and non-GJH.

GJH is seen three times more often in women[28,29]. In line with the literature, the proportion of women (66.7%) in the GJH group was three times higher than men (33.3%) in this study. A large population study revealed that knee or shoulder pain was more likely to be reported in individuals with GJH. Since it is seen more often, they are nearly four times more likely to avoid activities to prevent symptoms[30,31]. The GJH individuals in this study were asymptomatic. However, symptoms could not appear until later in adulthood because the subjects were young college students. This is why we believe it's critical to identify joint hypermobility as soon as possible.

Previous research revealed that the left side has a greater frequency of hypermobile joints[32-34]. Since we evaluated the total score of both sides, we do not know the score difference between the right and left sides, but studies results indicated that non-dominant elbow flexion and wrist extension muscle strength were statistically weaker on the non-dominant sides, which corresponded to the left side of the higher proportion of participants.

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

A study reported that sit and reach test results were higher in individuals with joint hypermobility than non-hypermobile individuals[35]. Czaprowski et al.[36] did not observe any significant differences in the muscle flexibility between girls and boys aged 10–13 with GJH in comparison with their non-GJH peers. Another study reported that the muscle flexibility of adults with GJH did not differ compared to non-GJH[37]. The present study showed that no significant difference was found in the sit and reach test scores between the groups indicating similar hamstring and lower back flexibility between the GJH and non-GJH groups.

The studies in GJH generally focused on lower extremity[6,38-42]. A few studies reported results related to upper extremity in individuals with joint hypermobility[29,31]. Some studies disclosed that shoulder, hip, and knee strength were significantly weaker in persons with joint hypermobility in some aspects of strength[12,29,37,43], although the other studies reported similar findings compared to nonhypermobile peers[12,29,37,43]. In these studies, Beighton criteria were used for determining GJH[12,29,37], but the protocols and equipment used to measure strength differed between these studies. As we evaluated the hypermobility with Beighton criteria, we only observed a significant difference in non-dominant elbow flexion and wrist extension muscle strength in the upper extremity muscle testing scores, dominant hand-grip strength, and dominant lateral pinch-grip strength and dominant/nondominant three-point pinch-grip strength tests between the groups. Previous studies did not find any relationship between hypermobility evaluated with the Beighton criteria and pinch-grip strength[44,45]. In contrast, this study revealed that dominant lateral pinch-grip, and dominant/non-dominant three-point pinch-grip strength were significantly weaker in the GJH group. Distal muscles of the upper extremities were found to be primarily responsible for the observed difference in muscle strength between the two groups. Further research assessing strength in individuals with higher Beighton scores as well as in men and women will support the existing body of knowledge.

Trunk stability is provided by the core muscles before the movement of the limbs during functional activities[46-48]. A recent study reported that forced expiratory maneuvers performed weaker by the people with GJH than those without GJH[49]. This may suggest that the core muscles, which include the abdominals, are major muscles of expiration and play an important role in forced expiration. Booshanam et al.[50] reported significantly poorer trunk, upper, and lower back alignment in individuals with benign joint hypermobility syndrome. It is reported that impaired transversus abdominis, erector spinae, quadratus lumborum, and latissimus dorsi muscles may deteriorate core stabilization, resulting in hypermobile individuals sitting with the trunk bent forward[51]. We evaluated the core muscle endurance with five tests and observed significant differences between groups of the variables in trunk flexion and side plank tests in favor of the non-GJH group. To our knowledge, core endurance has not yet been tested in the people with GJH. This study will contribute to our understanding of the role that core endurance plays in everyday activities and will make it easier to prescribe training aimed at enhancing or preserving this population's functionality. However, we would like to point out that the young adults who participated in this study were sedentary individuals who had not participated in any exercise program or sporting activity in the last six

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

months. Less active, more sedentary individuals may exhibit more reduced strength and endurance in muscles. However, this difference that we observed in some core muscle endurance tests shows that individuals with GJH may need to participate in an exercise program more than their non-GJH peers.

Hand-eye coordination is a complex cognitive ability that requires the eyes and hands to work simultaneously to complete activities[52]. Some studies reported a significant positive relationship between hand-eye coordination and core muscle strength[10,53]. We did not encounter any studies comparing hand-eye coordination in young adults with and without GJH. It has been reported in the literature that in children, alternate hand wall toss test scores correspond to >35 excellent, 30-35 good, 20-29 average, 15-19 fair, and <15 poor catches in 30 seconds[25,54]. The alternate hand wall toss test had an average score of 11.8 in research including 20 non-athletic participants who had low back pain; this is considered unsatisfactory according to the scale range[53]. In this study, the test scores were 13.85±4.93 for the GJH group and 16.11±5.75 for the non-GJH group, but no significant difference was observed between the groups. Low scores of the test for both groups may be related to the inclusion of sedentary or less active individuals in the study.

The study is not without its limits. The results we obtained cannot be generalized for older people because this study population consisted entirely of young adults. Furthermore, as we evaluated upper limb muscular strength solely, we are unable to project these results to lower extremity muscles. To investigate the impact of GJH on the strength and endurance of other muscle groups, larger cross-sectional investigations are required.

Conclusion

Hypermobility has been shown to raise the risk of musculoskeletal issues. Because of this, assessing hypermobility in patients referred to medical facilities with a range of musculoskeletal symptoms, increasing awareness of GJH patients to prevent injuries due to hypermobility, and strengthening muscles can all help give early remedies to the problems.

REFERENCES

1. Beighton PH, Grahame R, Bird H. Hypermobility of Joints. Fourth Editions. United Kingdom: Springer Science & Business Media; 2011.
2. Hakim AJ, Cherkas LF, Grahame R, et al. The genetic epidemiology of joint hypermobility: a population study of female twins. *Arthritis & Rheumatism: Official Journal of the American College of Rheumatology*. 2004;50(8):2640-2644.
3. Hakim AJ, Grahame R. Joint hypermobility. *Best Practice & Research Clinical Rheumatology*. 2003;17(6):989-1004.
4. Grahame R, Bird H, Child A. The revised (Brighton 1998) criteria for the diagnosis of benign joint hypermobility syndrome (BJHS). *The Journal of Rheumatology*. 2000;27(7):1777-1779.

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

5. Chahal J, Leiter J, McKee MD, Whelan DB. Generalized ligamentous laxity as a predisposing factor for primary traumatic anterior shoulder dislocation. *Journal of Shoulder and Elbow Surgery*. 2010;19(8):1238-1242.

6. Pacey V, Nicholson LL, Adams RD, et al. Generalized joint hypermobility and risk of lower limb joint injury during sport: A systematic review with meta-analysis. *The American Journal of Sports Medicine*. 2010;38(7):1487-1497.

7. Tingle A, Bennett O, Wallis A, Palmer S. The links between generalized joint laxity and the incidence, prevalence and severity of limb injuries related to physical exercise: A systematic literature review. *Physical Therapy Reviews*. 2018;23(4-5):259-272.

8. Smith R, Damodaran A, Swaminathan S, et al. Hypermobility and sports injuries in junior netball players. *British Journal of Sports Medicine*. 2005;39(9):628-631.

9. Scheper MC, Juul-Kristensen B, Rombaut L, et al. Disability in adolescents and adults diagnosed with hypermobility-related disorders: A meta-analysis. *Archives of Physical Medicine and Rehabilitation*. 2016;97(12):2174-2187.

10. Putra AL. The Contribution of arm muscle strength and coordination of hand eye towards chest pass skills in self development activities of basketball. *Atlantis Press*. 2020:427-430.

11. Faul F, Erdfelder E, Lang A-G, Buchner A. G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*. 2007;39(2):175-191.

12. Jindal P, Narayan A, Ganesan S, MacDermid JC. Muscle strength differences in healthy young adults with and without generalized joint hypermobility: A cross-sectional study. *BMC Sports Science, Medicine and Rehabilitation*. 2016;8(1):1-9.

13. Beighton P, Solomon L, Soskolne C. Articular mobility in an African population. *Annals of the Rheumatic Diseases*. 1973;32(5):413.

14. Wells KF, Dillon EK. The sit and reach - a test of back and leg flexibility. *Research Quarterly American Association for Health, Physical Education and Recreation*. 1952;23(1):115-118.

15. McGill SM, Childs A, Liebenson C. Endurance times for low back stabilization exercises: clinical targets for testing and training from a normal database. *Archives of Physical Medicine and Rehabilitation*. 1999;80(8):941-944.

16. Ito T, Shirado O, Suzuki H, et al. Lumbar trunk muscle endurance testing: An inexpensive alternative to a machine for evaluation. *Archives of Physical Medicine and Rehabilitation*. 1996;77(1):75-79.

17. McGill S. *Ultimate Back Fitness and Performance*. Third Edition. Canada: Orthopedic Physical Therapy Product Canada; 2006.

18. Douma R. *Clinical Muscle Strength Measurements: Reference Values and Reliability*. Holland: University of Groningen Press; 2021.

19. Schrama PP, Stenneberg MS, Lucas C, Van Trijffel E. Intraexaminer reliability of hand-held dynamometry in the upper extremity: A systematic review. *Archives of Physical Medicine and Rehabilitation*. 2014;95(12):2444-2469.

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

20. Andrews AW, Thomas MW, Bohannon RW. Normative values for isometric muscle force measurements obtained with hand-held dynamometers. *Physical Therapy*. 1996;76(3):248-259.

21. Bellace JV, Healy D, Besser MP, et al. Validity of the Dexter Evaluation System's Jamar dynamometer attachment for assessment of hand grip strength in a normal population. *Journal of Hand Therapy*. 2000;13(1):46-51.

22. Ong HL, Abdin E, Chua BY, et al. Hand-grip strength among older adults in Singapore: a comparison with international norms and associative factors. *BMC Geriatrics*. 2017;17(1):1-11.

23. Lindstrom-Hazel D, Kratt A, Bix L. Interrater reliability of students using hand and pinch dynamometers. *The American Journal of Occupational Therapy*. 2009;63(2):193-197.

24. McQuiddy VA, Scheerer CR, Lavalley R, et al. Normative values for grip and pinch strength for 6-to 19-year-olds. *Archives of Physical Medicine and Rehabilitation*. 2015;96(9):1627-1633.

25. Cho EH, Yun HJ, So WY. The validity of alternative hand wall toss tests in Korean children. *Journal of Men's Health*. 2020;16(1):10-18.

26. Beashel P, Taylor J. Fitness for Health and performance. *The World of Sport Examined*. 1997;55.

27. Wood R. Alternate hand wall toss test. Topend Sports. https://www.topendsports.com/testing/tests/wall-catch.htm. Published April 2005. Accessed date: 03.04.2024.

28. Russek LN, Errico DM. Prevalence, injury rate and symptom frequency in generalized joint laxity and joint hypermobility syndrome in a "healthy" college population. *Clinical Rheumatology*. 2016;35:1029-1039.

29. Scheper M, De Vries J, Beelen A, et al. Generalized joint hypermobility, muscle strength and physical function in healthy adolescents and young adults. *Current Rheumatology Reviews*. 2014;10(2):117-125.

30. Junge T, Henriksen P, Hansen S, et al. Generalised joint hypermobility and knee joint hypermobility: prevalence, knee joint symptoms and health-related quality of life in a Danish adult population. *International Journal of Rheumatic Diseases*. 2019;22(2):288-296.

31. Juul-Kristensen B, Østengaard L, Hansen S, et al. Generalised joint hypermobility and shoulder joint hypermobility, risk of upper body musculoskeletal symptoms and reduced quality of life in the general population. *BMC Musculoskeletal Disorders*. 2017;18(1):1-9.

32. Al-Jarallah K, Shehab D, Al-Jaser MT, et al. Prevalence of joint hypermobility in Kuwait. *International Journal of Rheumatic Diseases*. 2017;20(8):935-940.

33. Pountain G. Musculoskeletal pain in Omanis, and the relationship to joint mobility and body mass index. *Rheumatology*. 1992;31(2):81-85.

34. Al-Rawi ZS, Al-Aszawi AJ, Al-Chalabi T. Joint mobility among university students in Iraq. *Rheumatology*. 1985;24(4):326-331.

35. Akkaya KU, Burak M, Erturan S, et al. An investigation of body awareness, fatigue, physical fitness, and musculoskeletal problems in young adults with

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

hypermobility spectrum disorder. *Musculoskeletal Science and Practice*. 2022;62:102642.

36. Czaprowski D, Kędra A, Pawłowska P, et al. The examination of the musculoskeletal system based only on the evaluation of pelvic-hip complex muscle and trunk flexibility may lead to failure to screen children for generalized joint hypermobility. *PloS one*. 2015;10(3):e0121360.

37. Ewertowska P, Trzaskoma Z, Sitarski D, et al. Muscle strength, muscle power and body composition in college-aged young women and men with Generalized Joint Hypermobility. *Plos one*. 2020;15(7):e0236266.

38. Geiser C, Kim H, Kipp K. Individuals with generalized joint hypermobility demonstrate similar lower extremity muscle forces during a dynamic cutting task. *ISBS Proceedings Archive*. 2020;38(1):412.

39. Chaiparinya P, Gaogasigam C. Prevalence, frontal plane knee alignment, and lower limb joint pain and injury in generalized joint hypermobility in Thai physical therapy students. *Reumatologia/Rheumatology*. 2022;60(2):116-124.

40. Zsidai B, Piussi R, Thomeé R, et al. Generalized joint hypermobility leads to an 8-fold increase in the odds of sustaining a second ACL injury within 24 months of return to sport after ACL reconstruction. *Orthopaedic Journal of Sports Medicine*. 2023;11(3_suppl2):2325967123S00014.

41. Song J, Kang C, Jeon JH, Ham CU. Evaluation of the anterior talofibular ligament by stress ultrasound for assessing generalized joint hypermobility. *Foot & Ankle Orthopaedics*. 2020;5(4):2473011420S00453.

42. Turner EH, Markhardt BK, Cotter EJ, et al. Patients with generalized joint hypermobility have thinner superior hip capsules and greater hip internal rotation on physical examination. *Arthroscopy, Sports Medicine, and Rehabilitation*. 2022;4(4):e1417-e1427.

43. Liaghat B, Juul-Kristensen B, Frydendal T, et al. Competitive swimmers with hypermobility have strength and fatigue deficits in shoulder medial rotation. *Journal of Electromyography and Kinesiology*. 2018;39:1-7.

44. Massy-Westropp C, Massy-Westropp N, Wechalekar H. Normative values for pinch strength relationship with joint hypermobility as measured with the beighton criteria. *Journal of Hand Surgery Global Online*. 2023;5(3):272-276.

45. Mathiowetz V, Kashman N, Volland G, et al. Grip and pinch strength: normative data for adults. *Archives of Physical Medicine and Rehabilitation*. 1985;66(2):69-74.

46. Panjabi MM. The stabilizing system of the spine. Part I. Function, dysfunction, adaptation, and enhancement. *Journal of Spinal Disorders*. 1992;5:383-383.

47. Akuthota V, Ferreiro A, Moore T, Fredericson M. Core stability exercise principles. *Current Sports Medicine Reports*. 2008;7(1):39-44.

48. Bergmark A. Stability of the lumbar spine: A study in mechanical engineering. *Acta Orthopaedica Scandinavica*. 1989;60(sup230):1-54.

49. Varol BK, Şırayder U, Sandal M, Tuncer D. The effect of generalized joint hypermobility on functional capacity, pulmonary function, respiratory muscle strength, and chest expansion in healthy young adults. *Journal of Health Sciences and Medicine*. 2023;6(2):300-306.

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

50. Booshanam DS, Cherian B, Joseph CPA, et al. Evaluation of posture and pain in persons with benign joint hypermobility syndrome. *Rheumatology International*. 2011;31(12):1561-1565.
51. Lamari N, Beighton P. Mechanical consequences of joint hypermobility. *Hypermobility in Medical Practice*. Springer; 2023:63-71.
52. Telford RD, Cunningham RB, Telford RM, et al. Benefits of early development of eye–hand coordination: Evidence from the LOOK longitudinal study. *Scandinavian Journal of Medicine & Science in Sports*. 2013;23(5):e263-e269.
53. Reddy A, Arunachalam R, Anitha A. Correlation between core muscle strength and hand-eye coordination in non athletes. *International Journal of Physiotherapy*. 2017:291-295.
54. Tanineh W, Halaweh H. Cardiorespiratory fitness, motor coordination, and academic achievement in school students (11-13 years). *Global Pediatric Health*. 2023;10:2333794X231207311.

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr