The Relationship between Core Endurance, Hand Grip Strength, and Reaction Time in Young Adults*

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Abstract

Aim: The aim of the study was to examine the relationship between core endurance, hand grip strength, and reaction time in young adults.

Method: Fifty-two undergraduate students with an average age of 21.07 (1.46) were included in this cross-sectional, observational study. Core endurance (McGill's Core Endurance Tests), hand grip strength (Jamar Hydraulic Hand Dynamometer), and the lower extremity reaction time (OptoGait device) were assessed.

Results: There was a moderate, positive correlation between the left-right trunk lateral endurance test and the right (respectively; r=0.51, r=0.47, p<0.001) and left-hand grip strength (respectively; r=0.52, r=0.51, p<0.001). A weak, negative correlation was found between the left-right trunk lateral endurance test and right lower extremity reaction time (respectively; r=-0.38, p=0.005; r=-0.39, p=0.004). There was a weak, negative correlation between left- and right-hand grip strength and right lower extremity reaction time (respectively; r=-0.32, p=0.02; r=-0.37, p=0.006). Additionally, in participants with the right dominant leg, a moderate, negative correlation was found between the right lower extremity reaction time and right-hand grip strength (r=-0.40, p=0.01) and a weak, negative correlation with left and right trunk lateral endurance test (respectively; r=-0.35, p=0.03; r=-0.33, p=0.04).

Conclusion: The findings of this study, which demonstrate that there was a relationship between core endurance, hand grip strength, and reaction time, can provide a valuable resource for professionals working in this field. The association between these parameters may be helpful in guiding exercise planning in subjects such as injury, rehabilitation process, and increasing performance in sports.

Keywords: Core, muscle strength, physical fitness, reaction time.

Genç Erişkinlerde Kor Endurans, El Kavrama Kuvveti ve Reaksiyon Süresi Arasındaki İlişki

Öz

Amaç: Çalışmanın amacı, genç erişkinlerde kor endurans, el kavrama kuvveti ve reaksiyon süresi arasındaki ilişkiyi incelemektir.

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ETHICAL STATEMENT: This study was carried out with the approval of the Ethics Committee of Fenerbahçe University, dated 20/07/2022 and numbered 20.2022fbu. A signed subject consent form in accordance with the Declaration of Helsinki was obtained from each participant.

Yöntem: Bu kesitsel ve gözlemsel çalışmaya yaş ortalaması 21,07 (1,46) olan 52 lisans öğrencisi dahil edilmiştir. Kor enduransı (McGill'in Kor Endurans Testleri), el kavrama kuvveti (Jamar Hidrolik El Dinamometresi) ve alt ekstremite reaksiyon süresi (OptoGait cihazı) değerlendirilmiştir.

Bulgular: Sol-sağ gövde lateral kor enduransı testi ile sağ (sırasıyla; r=0,51; r=0,47; p<0,001) ve sol el kavrama kuvveti (sırasıyla; r=0,52; r=0,51; p<0,001) arasında orta düzeyde, pozitif bir korelasyon bulundu. Sol-sağ gövde lateral kor enduransı testi ile sağ alt ekstremite reaksiyon süresi (sırasıyla; r=-0,38; p=0,005; r=-0,39; p=0,004) arasında zayıf, negatif bir korelasyon bulundu. Sol ve sağ el kavrama kuvveti ile sağ alt ekstremite reaksiyon süresi arasında da zayıf, negatif bir korelasyon vardı (sırasıyla; r=-0,32; p=0,02; r=-0,37; p=0,006). Ayrıca, sağ dominant bacağa sahip katılımcılarda, sağ alt ekstremite reaksiyon süresi ile sağ el kavrama kuvveti arasında orta düzeyde, negatif bir korelasyon (r=-0,40; p=0,01) ve sol ve sağ gövde lateral kor enduransı testi ile zayıf, negatif bir korelasyon (sırasıyla; r=-0,35; p=0,03; r=-0,33; p=0,04) bulundu.

Sonuç: Bu çalışmanın bulguları, kor enduransı, el kavrama kuvveti ve reaksiyon süresi arasında bir ilişki olduğunu göstermektedir ve bu alanda çalışan profesyoneller için değerli bir kaynak sağlayabilir. Bu parametreler arasındaki ilişki, yaralanma, rehabilitasyon süreci ve sporda performans artışı gibi konularda gerekli egzersizlerin planlanmasında faydalı olabilir.

Anahtar Sözcükler: Kor, kas kuvveti, fiziksel uygunluk, reaksiyon süresi.

Introduction

Physical fitness is the ability to perform occupational, recreational and daily activities successfully without experiencing fatigue[1]. It includes both health-related and performance-related components[2]. Improving health-related physical fitness, involving cardiovascular endurance, muscular strength and endurance, flexibility, and body composition, is encouraging to improve health. Additionally, the ability to perform physical activity concerning agility, power, speed, balance, coordination, and reaction time is defined by skill-related physical fitness[3], which is crucial for performance[4]. The role of these physical fitness parameters in dropping the fall risk in the elderly was detailedly reported by a review which recommended that lower extremity flexibility, reaction time, and strength should be considered when creating fall intervention exercise programs[5]. Considering its effect on health, injury prevention and improvement in performance, it is essential to examine core parameters of physical fitness[6].

The core can be defined as the muscle groups that support the spine, which play an effective role in the transfer of force in the lower and upper extremities, surrounded by the abdominals anteriorly, the paraspinal and gluteal posteriorly, the diaphragm as the roof, and the pelvic floor and hip girdle muscles below[7,8]. There are also anatomical definitions that express the core is a structure surrounded by muscles that function synergistically to generate and reduce power and provide dynamic stabilization[9]. Core stability has no clear definition; it may vary according to researchers and authors[10]. It is called the "powerhouse" which is the basis of all extremity movements and is important for maximizing force generation and minimizing joint loads in each activity[11]. It is thought that the strength of the core region, which is known to be connected through the kinetic chain with the lower and upper extremities, will improve upper and lower extremity function[12]. Core strength is an important performance indicator; thus, core muscles help transfer energy to the extremities while doing activities. Functional movements are highly dependent on the core region; thus, low strength and endurance of the core muscles may predispose to injury[13].

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Another important performance indicator is upper extremity strength. Hand grip strength, which is one of the determinants of upper extremity strength, is the result of strong flexion of all finger joints with the maximum force that the person can apply under normal biokinetic conditions[14]. Grip strength is considered to offer an objective index of the practical integrity of the upper extremity. It is the widely established, reliable and valid instrument for determining the value of treatment approaches[15,16]. Many activities performed in daily life require the controlled use of the trunk and abdominal muscles, that is, effective core muscle strength and endurance when working with the upper extremities. However, there are many studies conducted separately about hand grip strength and core muscle stimulation in the literature, there are very limited studies on the association between the two parameters[12,17].

The relationship between the core region and the upper extremity, as well as its relationship with the lower extremity, has been extensively studied in the literature. The importance of the core area has been reported in terms of general performance improvement or protection from injuries[18,19]. Available evidence has also shown a strong association between improved reaction time and reduced risk of lower extremity injury[20]. Although there are many studies conducted separately for reaction time and core muscle activation, there are very limited studies on the correlation between the two parameters[21]. Reaction time measures how quickly an organism responds to a stimulus, defined as the interval between the stimulus application and the subsequent response. This physical skill is based on human performance and is considered a key parameter of physical fitness. While the significance of reaction time is well-documented, and research has explored the relationship between upper extremity reaction times and hand grip strength across various populations[21,22], no studies have specifically examined the link between lower extremity reaction time and hand grip strength in young adults. Consequently, this study was designed to investigate the association between core muscle endurance, hand grip strength, and reaction time in young adults.

Material and Methods

Participants

The study consisted of 52 volunteer undergraduate students (22 males and 30 females) in the 1st, 2nd, and 3rd classes in the Physiotherapy and Rehabilitation Department, considering the specified inclusion and exclusion criteria. To agree to participate in the study after being informed, to be between the ages of 18-25 were the inclusion criteria. The exclusion criteria of the study were as follows: To have an orthopaedic and neurological dysfunction that may prevent the evaluation, a history of low back pain, recent surgery and/or trauma, systemic diseases, and to refuse to participate in the study after being informed.

Outcome Measures

Demographic information such as age, weight, height, and gender, as well as self-reported information, was collected during the enrolment of the participants. McGill's Core Endurance tests[23] were used to evaluate core endurance. The Jamar Hydraulic hand dynamometer[24] was employed to measure hand grip strength, and the OptoGait device was utilized to assess lower extremity reaction time[25]. The measurements started with a reaction time measurement, then, hand grip strength was assessed, and finally, core endurance tests were conducted. A 10-minute break was given between the tests. The tests began in the morning, at least 2 hours after the meal, with participants having a low level of fatigue. All tests for a participant were conducted on the same day by an experienced physiotherapist. Participants were familiarized with the tests before it starts, and verbal support was provided throughout.

Evaluation Form

Demographic data of individuals (age, gender, marital status), whether they have metabolic disorders, presence of pain, drugs used, exercise status, anthropometric measurement values [height, weight, body mass index (body weight (kg)/ height (m^2)], dominant hand/leg and a detailed data collection form in which data obtained as a result of core muscle endurance, right and left-hand grip strength, and reaction time measurements are recorded.

Anthropometric Measurements

The “Tanita BC 730 Body Analysis Scale”[26] was used to measure participants' weight and body mass index (BMI). Participants removed their shoes and socks and stood on the scale with their heels touching the electrodes and knees fully extended. Height was measured using a tape measure attached to a flat wall.

McGill’s Core Endurance Tests: McGill determined a valid and reliable set of tests [trunk flexors endurance test, trunk extensors endurance test (Biering-Sorensen) and lateral bridge tests)] to demonstrate trunk muscle endurance, and these tests have been shown to have reliability coefficients between 0.97 and 0.99. The purpose of endurance tests is to keep the person in a static position for as long as possible[23].

Trunk Flexors Endurance Test: The Trunk Flexors Endurance Test begins with the participant in a seated position, with the trunk supported at a 60° flexion angle. To minimize hip flexor involvement, the knees are bent to approximately 90°, and the feet must remain in contact with the ground without external fixation. The arms are crossed over the chest. Once the trunk support is removed, the participant attempts to maintain the position for as long as possible. The test is concluded when the participant can no longer hold the position. Time is manually recorded using chronograph stopwatches (Technos, YP2151/8P, BR) to the nearest 0.01 second[23].

Trunk Extensors Endurance Test (Biering-Sorensen): The Trunk Extensors Endurance Test, also known as the Biering-Sorensen test, assesses the isometric endurance of the trunk extensor muscles. During the test, the participant lies prone on a treatment table with their lower body, from the superior border of the iliac crest downward, secured to the table by a physiotherapist. The pelvis, hips, and knees are stabilized, while the trunk and upper extremities are supported by a chair at the same height as the table surface. Once the chair is removed, the participant maintains a prone position, holding their upper body horizontally without support. Hands are placed on the ears, elbows are extended outward and aligned with the trunk, and the head is kept in a neutral position. The participant holds this position until they can no longer resist the force of gravity due to fatigue. The test concludes when the participant's horizontal position deteriorates and the trunk begins to flex. The duration is recorded in seconds using chronograph stopwatches (Technos, YP2151/8P, BR)[23,27].

Lateral Bridge Test: This test is used to evaluate the endurance of the oblique muscle groups in the trunk. To begin, the participant lies on their right side with legs extended and stacked on top of each other. The right elbow is positioned directly under the right shoulder, and the right forearm is placed on the ground with the palm facing down to provide support. The left arm is either placed along the side of the body or across the chest. From this starting position, the participant lifts their hips off the ground into a side bridge position, forming a straight line from head to feet. The test is terminated when the pelvis drops to the bed or when the participant is unable to maintain proper posture[23,28].

Evaluation of Hand Grip Strength: Hand grip strengths were measured with the "Jamar Hydraulic Hand Dynamometer". Several studies have stated the high reliability and/or validity of the Jamar dynamometer and thus it is the gold standard for measurement of hand grip strength[29,30]. Participants were requested to indicate the hand with which they write in order to determine their dominant hand prior to the test. The standard test position suggested by the American Association of Hand Therapists were used[31]. Participants were positioned on a flat surface, sitting upright, knees and hips flexed to 90°, elbows flexed to 90°, forearm in a neutral position, wrist 0-30° flexed, and 0-5⁰ ulnar deviation. The grip handle of the dynamometer is adjusted to the hand length of each participant to achieve an optimum grip position. During the measurement, it was asked to squeeze the handle of the dynamometer strongly and then to hold the position for 3 seconds. The measurement was made alternately and 3 times for both hands. The average values were taken for the right and left hands after the measurements, and the force was recorded in 'kg'[24]. A 1-minute break was taken between measurements to prevent fatigue[32].

Evaluation of Reaction Time: The reaction time was measured with the OptoGait (Microgate Italia, Bolzano-Bozen, Italy) device. OptoGait is a motion analysis technology that is portable and uses high-density photoelectric cells between the transmitter and receiver rods when measuring[25]. In this study, the visual reaction test in the device was used. As soon as the red circle on the device screen turned green, the participant was asked to perform the one-leg raising and lowering movement that we determined to measure the reaction time of the lower extremity, with both feet fixed on the floor, knees in full extension, hips in neutral position, and arms at the side, and the reaction time was measured in seconds by the device. The test was performed three times for each of the legs, and the average of the reaction times obtained was recorded. A 1-minute break was taken between measurements to prevent fatigue. Before the start, the test was shown to the participants[33].

Before the test, low amplitude pushes were applied from the front and back to determine the dominant leg while talking to the participant constantly, and it was observed which leg the participant put forward or back in order not to fall. The leg used by the participant was recorded as the dominant leg[33].

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Ethical Statement

This study was an observational, cross-sectional study that was approved by the local Ethics Committee (20.07.2022, Project no: 20.2022fbu) and conducted according to the Helsinki Declaration. Written informed consent for the use of the participants' data for research projects was completed by all participants at the time of enrolment.

Statistical Analysis

The GPower software package (GPower, Version 3.1.9.4, Franz Faul, Universität Kiel, Germany) was employed to determine the required sample size. The sample size calculation was based on the "correlation bivariate normal model" to assess the relational dynamics between the variables. It was determined that a minimum sample size of 46 subjects was necessary to achieve 95% power, with an effect size of $d = 0.50$, a significance level of $\alpha = 0.05$ for Type I error, and $\beta = 0.05$ for Type II error. For the statistical analysis of the study data, the "Statistical Package for Social Sciences" (SPSS) Version 20.0 (SPSS Inc., Chicago, IL, USA) was utilized. Variables were described using their mean, standard deviation, and percentage values. Pearson correlation analysis was conducted to examine the relationships between the scales. Correlation coefficients were interpreted as follows: 0.00–0.10: negligible, 0.10–0.39: weak, 0.40–0.69: moderate, 0.70–0.89: strong, and 0.90–1.00: very strong correlation[34]. A p-value of <0.05 was considered statistically significant in all analyses.

Results

Sixty undergraduates, ranging from 1st to 4th year, were invited to participate, but 8 did not meet the eligibility criteria. Consequently, a total of 52 participants were included. No unexpected effects were observed during the assessments.

The demographic and clinical characteristics of the participants are summarized in Table 1. The sample of this study included 22 males (42.3%) and 30 females (57.7%) with a mean age of 21.18±0.85 years. The average body mass index (BMI) was 22.12±2.84 kg/m^2. In all participants, the right hand was dominant, while 37 participants (71.2%) had a dominant right leg, and 15 participants (28.8%) had a dominant left leg.

Table 1. Sociodemographic characteristics of the participants.

Characteristics	**n (52)**
Sex (F/M), n (%)	30 (57.7) / 22 (42.3)
Age (year), mean (SD)	21.18 (0.85)
Height (meter), mean (SD)	1.70 (0.09)
Weight (kg), mean (SD)	65.15 (13.62)
BMI (kg/m^2), mean (SD)	22.12 (2.84)
Dominant leg	
Right	37 (71.16)
Left	15 (28.84)

SD: standard deviation, F: female, M: male, BMI: body mass index

The correlation between core endurance, hand grip strength, and reaction time parameters is shown in Table 2. Left-right trunk lateral endurance test was moderately and positively correlated with the right-hand grip strength (respectively, r=0.51, r=0.47, p<0.001). A moderate, positive correlation was found between left-right trunk lateral endurance tests and left-hand grip strength (respectively, r=0.52, r=0.51, p<0.001). A weak, negative correlation was found between the left-right trunk lateral endurance test and right lower extremity reaction time (respectively, r=-0.38, p=0.005; r=-0.39, p=0.004). There was no relationship between the core endurance parameters and the left lower extremity reaction time of these participants (p>0.05). Left- and right-hand grip strength was weakly and negatively correlated with right lower extremity reaction time (respectively; r=-0.32, p=0.02; r=-0.37, p=0.006). There was no correlation between left- and right-hand grip strengths and left lower extremity reaction time (p>0.05).

Table 2. Correlation between core endurance, hand grip strength and reaction time parameters.

Variables		LLERT	RLERT	LHGS	RHGS	TFET	LTLET	RTLET	TEET
LLERT (sn)	r	1	.447**	-.230	-.205	-.059	-.078	-.224	-.029
	p		**.001**	.102	.145	.680	.585	.111	.838
RLERT (sn)	r	.447**	1	-.325*	-.379**	-.221	-.384**	-.395**	-.090
	p	**.001**		**.019**	**.006**	.115	**.005**	**.004**	.527
LHGS (kg)	r	-.230	-.325*	1	.925**	.267	.522**	.511**	.191
	p	.102	**.019**		**.000**	.056	**.000**	**.000**	.176
RHGS (kg)	r	-.205	-.379**	.925**	1	.151	.512**	.470**	.135
	p	.145	**.006**	**.000**		.286	**.000**	**.000**	.342
TFET (sn)	r	-.059	-.221	.267	.151	1	.406**	.367**	.442**
	p	.680	.115	.056	.286		**.003**	**.007**	**.001**
LTLET (sn)	r	-.078	-.384**	.522**	.512**	.406**	1	.828**	.316*
	p	.585	**.005**	**.000**	**.000**	**.003**		**.000**	**.022**
RTLET (sn)	r	-.224	-.395**	.511**	.470**	.367**	.828**	1	.363**
	p	.111	**.004**	**.000**	**.000**	**.007**	**.000**		**.008**
TEET (sn)	r	-.029	-.090	.191	.135	.442**	.316*	.363**	1
	p	.838	.527	.176	.342	**.001**	**.022**	**.008**	

** Correlation is significant at the 0.01 level (2-tailed), *Correlation is significant at the 0.05 level (2-tailed), LLERT: left lower extremity reaction time, RLERT: right lower extremity reaction time, LHGS: left-hand grip strength, RHGS: right-hand grip strength, TFET: trunk flexor endurance test, LTLET: left trunk lateral endurance test, RTLET: right trunk lateral endurance test, TEET: trunk extensor endurance test

The correlation between lower extremity reaction time and other parameters in participants with right and left-dominant legs are shown in Table 3. In participants with right right-dominant leg, a moderate, negative correlation was found between the right lower extremity reaction time and right-hand grip strength (r=-0.40, p=0.01). Additionally, there was a weak, negative correlation between right lower extremity reaction time and left and right trunk lateral endurance test (respectively; r=-0.35, p=0.03; r=-0.33, p=0.04). In participants with left dominant leg, no correlation was found between left lower extremity reaction time and other parameters.

Table 3. Correlation between lower extremity reaction time and other parameters in participants with right and left dominant legs.

Variables		LLERT	RLERT	LHGS	RHGS	TFET	LTLET	RTLET	TEET
Participants with right dominant leg (n=37)									
RLERT (sn)	r	,423**	1	-,264	-,402*	-,190	-,356*	-,331*	-,111
	p	**,009**		,114	**,014**	,260	**,030**	**,045**	,512
Participants with left dominant leg (n=15)									
LLERT (sn)	r	1	,523*	-,175	-,088	-,033	,127	-,248	-,137
	p		**,046**	,532	,754	,906	,652	,373	,627

** Correlation is significant at the 0.01 level (2-tailed), *Correlation is significant at the 0.05 level (2-tailed), LLERT: left lower extremity reaction time, RLERT: right lower extremity reaction time, LHGS: left-hand grip strength, RHGS: right-hand grip strength, TFET: trunk flexor endurance test, LTLET: left trunk lateral endurance test, RTLET: right trunk lateral endurance test, TEET: trunk extensor endurance test

Discussion

The aim of this study was to explore the relationship between core muscle endurance, hand grip strength, and reaction time in young adults. The result of this study revealed that core endurance, measured by the trunk lateral endurance test, demonstrated moderate and positive correlations with left- and right-hand grip strength. Additionally, it was weakly and negatively correlated with right lower extremity reaction time. The left- and right-hand grip strength was weakly and negatively correlated with right lower extremity reaction time. According to these findings, a higher trunk strength is associated with upper extremity strength and reaction time.

Core endurance affects functional movements, and improper core endurance is highly associated with injuries. The core region is connected through the kinetic chain with the body parts and is very important for the function of the upper and lower extremities[35]. Thus, it is important to evaluate the relationship between core endurance and the performance parameters of the extremities. Solanki et al. whose purpose was to find out the correlation between hand grip strength and core muscle activation of the age group 18 to 25 reported a weak correlation between hand grip strength with core muscle activation[12]. Another study showed that strengths of back and abdominal muscles were connected with hand grip strength in the female participants, and back strength was related with lower extremity function in females and males[17]. Our study showed a moderate, positive relation between core endurance and hand grip strength that is consistent with the results of these studies. This finding may be explained by the fact that the core region exhibits an anatomical and biomechanical interconnection with the extremities, characterized by a prominent muscular linkage[36].

Reaction time, an important parameter for performance, is strongly associated with the risk of injuries. Especially in the process of preventing injuries to the lower extremities, it is of great importance that the person can adapt to sudden reactions and react quickly[37]. Bıyıklı et al. aimed at investigating the relationship between reaction time performances and core muscle strength and durability of the swimmers of an average age of 21. They concluded that there was a relation between right-hand visual reactions and plank measurement values[21]. Our study demonstrated a weak and negative correlation between core endurance and lower extremity reaction time. These findings may be explained by the fact that the lower extremity moves through core stabilization and power transfer, which are encouraged by the activation of the core muscles. In addition, the activation of the kinetic chain between the lower extremity and core area may affect the reaction time.

Choudhary et al. discovered that hand grip strength, a measure of muscle strength, was linked to better reaction time and noted that non-cognitive indicators like hand grip strength have a closer association with reaction time[38]. Also, a recent study showed how to hand grip strength increased as lower extremity reaction time decreased in older adults, consistent with the results of this study[39]. Additionally, our research has revealed that there was a correlation between right lower extremity reaction time and core endurance and hand grip strength, while the absence of correlation on the left side are similar to the results from previous studies. Bıyıklı et al. found a relation between right-hand reaction time and the core[21] and Choudhary et al. showed a negative correlation between at dominant hand grip strength and visual reaction time[38].

The main limitation of our study is the small number of participants. Secondly, the fact that the results are not categorized and evaluated according to gender can be considered as a limitation. Additionally, due to the cross-sectional design of the study, causality cannot be inferred, which should also be acknowledged as a limitation.

Conclusion

The research highlighted the relationship between core endurance, hand grip strength, and reaction time, noting these as significant markers of physical fitness. Given our results, considering the previously documented benefits of the analysed parameters in terms of injury prevention, performance enhancement, and effectiveness in treatment, we believe that the knowledge of the identified relationship will serve as a valuable guide for individuals working in this field. Future research could further examine different age groups and design various exercise programs based on these relationships

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Data availability: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethics Committee Approval: This study was approved by the Fenerbahçe University Ethics Committee (20.07.2022, Project no: 20.2022fbu). Written informed consent for the use of the participants' data for research projects was completed by all participants at the time of enrolment.

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