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Does ankle plantar and dorsiflexion affect fifty-meter swimming time in swimmers?

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Abstract

The purpose of this study was to determine the relationships between ankle plantar and dorsiflexion and the four swimming styles in girl and boy swimmers. The study consisted of 20 girls (Mage= 16.50 ± 0.51 years) and 20 boys (Mage= 16.50±0.51 years), for a total of 40 swimmers volunteer individuals. Anthropometric and body composition measures were obtained including body height, body mass, fat %, fat free mass (FFM). Besides, ankle flexibility was assessed by measuring ankle plantar flexion and ankle dorsiflexion and four style swimming performance was obtained in official competition. All values are presented as mean ±SD and median (min – max). Student t-test was performed on each independent variable to compare differences between the genders for the parametric test, for the nonparametric tests, it was used Mann Whitney U test. For the correlation analysis between two variables, Pearson correlation coefficients were used to describe correlations for the parametric variables, spearman's correlation coefficients were used for the non-parametric variables. Significant high and moderate level of correlations was found between ankle plantar flexion, dorsiflexion (right and left), and average flexion and four style swim time in girl swimmers ($p<0.001$). In boy swimmers, there was found a moderate level of correlation between left, and average ankle dorsiflexion except right ankle dorsiflexion and swimming time for all styles ($p<0.05$). In conclusion, the study findings especially point towards the potential importance of ankle plantar and dorsiflexion in 50 m swimming time for all styles in girl swimmers.

Keywords: Dorsiflexion; Gender; Plantar Flexion; Swimming.

Yüzücülerde Ayak Bileği Plantar ve Dorsifleksiyon Elli Metre Yüzme Süresini Etkiler Mi?

Özet

Bu çalışmanın amacı kız ve erkek yüzücülerde ayak bileği plantar ve dorsifleksiyon ile dört yüzme stili arasındaki ilişkiyi belirlemektir. Bu araştırmaya 20 kız (Ortyaş= 16.50 ± 0.51 yıl) ve 20 erkek (Ortyaş= 16.50±0.51 yıl) olmak üzere toplam 40 yüzücü gönüllü olarak katılmıştır. Antropometrik ve vücut kompozisyonu olarak boy uzunluğu, vücut ağırlığı, vücut yağ yüzdesi ve yağ dışı kütle (FFM) ölçümleri yapılmıştır. Ayrıca, ayak bileği esnekliği, ayak bileği plantar ve dorsifleksiyon ölçümleri yapılmış ve resmi yarışmada dört farklı stil yüzme performansı elde edilmiştir. Tüm değerler ortalama ±SS ve medyan (min – maks) olarak sunulmuştur. Parametrik test için cinsiyetler arası farklılıkları karşılaştırmada student t-testi, parametrik olmayan testler için Mann Whitney U testi kullanılmıştır. İki değişken arasındaki korelasyon analizinde parametrik değişkenler için Pearson korelasyon katsayısı, parametrik olmayan değişkenler için spearman korelasyon katsayısı kullanılmıştır. Kız yüzücülerde ayak bileği plantar fleksiyon, dorsifleksiyon (sağ ve sol) ve ortalama fleksiyon ile dört yüzme stili süreleri arasında anlamlı düzeyde yüksek ve orta düzeyde korelasyon bulunmuştur ($p<0.001$). Erkek yüzücülerde ise, tüm stillerde sağ ayak bileği dorsifleksiyon dışında sol ve ortalama ayak bileği dorsifleksiyonda orta düzeyde korelasyon bulunmuştur ($p<0.05$). Sonuç olarak, araştırma bulguları, özellikle kız yüzücülerde tüm stiller için 50 m yüzme süresi ayak bileği plantar ve dorsifleksiyonunun önemini göstermektedir.

Anahtar Kelimeler: Cinsiyet, Dorsifleksiyon, Plantar Fleksiyon, Yüzme

INTRODUCTION

Flexibility is a measure of the range of motion (ROM) that is one of the most important components of both health and performance related to physical fitness, known to affect performance and health (17). The ROM of a particular joint is affected by a number of factors that consist of connective tissue structure, activity level, age, and sex Baechle and Earle (2). Flexibility is a critical part of the training that may provide benefits in some cases, including maintaining appropriate muscle lengths, improving muscle balance and muscular weaknesses, and reduce the risk of injury, and also can improve posture and the ability to move to athletic training (17). Each sport and activities have specific requirements for ROM that related to the movements based on sport-specific requirements Baechle and Earle (2). Sport of swimming requires the utilization of plantar and dorsal flexion, which is the essential components to maintain foot strokes and a balanced position. The plantar flexion and dorsiflexion range of motion is necessary to use in the feet in order to move forward to travel a certain distance in the water (1).

Many coaches and swimmers are seeking ways to improve performance to be successful, and especially in sports that based on time, to be a winner is determined by merely fractions of a second. In competitive swimming, performance is identified by the time utilized to finish the race distance. Therefore, all factors that may contribute to athletic performance and success, should be examined. One area interested by coaches and swimmers to improve is ankle flexibility, particularly plantar flexion (15). More flexible ankles are believed by coaches, to contribute to faster kicking ability McCullough et al., (10). A good range of motion, flexibility, and above-average musculoskeletal forces produce powerful whip kick propulsion during the movement (23). Previous studies conducted in swimmers examining the effect of ankle joint flexibility consisted the areas including dolphin kick performance (24), kick performance on the breaststroke (8), (23), flutter kick performance (15), kinetic characteristics of the ankle joint and the performance of freestyle kick (21), kicking efficiency and kinematics analysis (22), dynamic balance ability to angle range of motion (1). The current investigation focused on ankle joint flexibility for both girl and boy swimmers, and it aimed to determine the relationship of plantar flexion and dorsiflexion range of motion on swimming time based on genders in four swimming styles, and to compare to the angle range of motion between the genders. It was hypothesized based on the above-mentioned cases that the angle flexibility may influence the swimming time.

MATERIALS AND METHODS

Participants

A total of forty college swimmers (girl: N=20 and boy: N=20) participated in the study. Subject characteristics are described in Table 1. Before the participating to the study, the written informed consent form was obtained from their parents. The detailed explanation of the risks and benefits of the study for each participant before the investigation. The study was approved by the Ethics Committee of Hitit university (2018-11).

Anthropometric And Body Composition

The body height and mass of the subjects were measured to the nearest 0.5 cm and 0.1 kg respectively. Body mass index was calculated based on body mass (kg) / body height (m2). Body compositional assessment was performed by an expert person. Skinfold thickness (mm) was measured for girls and boys at three identified anatomical landmark sites. The anatomical sites included triceps, suprailium, and thigh for girls; chest, abdomen, thigh for boys, it performed using a Holtain caliper. Body fat (BF) percent for boys and girls was calculated by using Jackson- Pollock equation (11).

Ankle Flexibility Measurements

Ankle flexibility was measured using goniometric measurements by the same experienced person. Subjects sat on a flat bench with legs extended. To measure ankle plantar flexion and dorsiflexion range of motion were measured using the method described by Ekstrand et. al. (5).

Swimming Performance

The swimming performance was obtained in official competition that was held during the 50-meter season in 2018. It was recorded with one-hundredth of a second accuracy for each freestyle, backstroke, breaststroke, and butterfly swimming styles.

Statistical Analysis

Statistical analysis of the data was performed using SPSS 20.0 (Statistical Package for the Social Sciences, Version 22.0, SPSS Inc., Chicago, IL, USA).

Some of the variables presented in the tables were normally distributed, some also were not. Before using parametric and nonparametric tests, the assumption of normality, distribution was verified using the Shapiro-Wilk test. All values are presented as mean ±SD and median (min – max). Student t-Test was performed on each independent variable to compare differences between the genders for the parametric test, for the nonparametric tests, it was used Man Whitney U test. For the correlation analysis between two variables, Pearson correlation coefficients were used to describe correlations for the parametric variables, spearman's correlation coefficients were used for the non-parametric variables. To interpret the correlation coefficients for the reference values was regarded respectively $0.00 < r < 0.25$ as very weak, $0.26 < r < 0.49$ as weak, $0.50 < r < 0.69$ as moderate, $0.70 < r < 0.89$ as strong and $0.90 < r < 1.00$ as very strong and the level of significance was set at $p < 0.05$ for all tests.

RESULTS

Mean and standard deviation and median scores on characteristics of the participants for girl and boy swimmers are presented in Table 1. The data indicated statistical differences in BH, BM, fat %, FFM between the genders. No significant difference was found between genders according to biological age ($p>0.05$). The boys were taller ($p<0.05$), heavier ($p<0.05$) and had low body fat %, and more FFM ($p<0.05$) than the girls. In addition, the boy swimmers had more training experience than the girl swimmers ($p<0.05$) (Table 1). Mean and standard deviation and median scores on ankle dorsi and plantar flexion (right and left) the participants for girl and boy swimmers are presented in Table 2. The statistical differences were found in right, left, and average ankle plantar flexion between the genders ($p<0.05$) (Table 2).

According to the obtained competition results for both genders, the scores and percentage of difference are given in Table 3. The statistical differences were found in freestyle, breaststroke, and butterfly swimming competition scores between the genders ($p<0.05$) (Table 3).

Table 4 presents the correlational relationships among the variables. In girl swimmers: a significantly high level of correlations was found between left and average ankle dorsiflexion and swimming time for all styles, but right ankle dorsiflexion negatively correlated as moderate level. There was a moderate negatively correlation between right, left and average ankle plantar flexion and swimming time for all swimming styles ($p<0.05$). In boy swimmers: there was found a moderate level of correlation between left, and average ankle dorsiflexion except right ankle dorsiflexion and swimming time for all styles ($p<0.05$). Right, left and average ankle plantar flexion was not significantly correlated with swimming time for all styles ($p>0.05$) (Table 4).

Table 1. Characteristic of the participants, according to the genders.

Variables	Girls	Boys	D (%)	p
Age (year)	16.50 (16-17) (16.50±0.51)	16.50 (16-17) (16.50±0.51)	0	1.000b
BH (cm)	164.9±7.4	174.4±5.81	5.76	<0.001a
BM (kg)	59.1 (43-68) (57.81±7.23)	66 (53-95) (67.00±10.56)	15.89	0.002b
Fat (%)	10.55 (8.81-17.77) (11.58±2.47)	6.33 (4.26-21.31) (7.58±4.79)	-34.54	<0.001b
FFM (kg)	53.18 (37.65-60.64) (51.06±6.15)	61.97 (48.42-75.30) (61.52±6.54)	20.48	<0.001b
TE (year)	6.5 (5-9) (6.30±1.59)	7 (5-9) (7.40±1.63)	15.00	0.023b

Statistical significance $p<0.05$; BH: body height; BM: body mass; D: difference; FFM: fat free mass (kg); TE: training experience; a:student's t test with mean ± standard deviation; b:Mann Whitney U test with median (min-max) (mean ± standard deviation).

Table 2. The data of the ankle dorsiflexion and plantar flexion, according to the genders.

Variables - ankle	Girls	Boys	D (%)	p
Dorsi flexion, right (°)	22.95±4.24	21.95±2.32	-4.35	0.211a
Plantar flexion, right (°)	102.0±12.51	88.75±15.80	-12.99	0.005a
Dorsi flexion, left (°)	24 (12-27) (21.75±5.05)	22.25 (14-33) (21.19±5.16)	-2.57	0.862b
Plantar flexion, left (°)	104 (74-123) (101.60±14.65)	80 (69-118) 84.85±16.68	-16.48	0.002b
Dorsi flexion average (°)	23.5 (12.50-27.50) (22.35±4.48)	22.12 (17.50-27.00) (22.07±3.26)	-1.04	0.823b
Planter flexion average (°)	103.25 (77.50-121.50) (101.80±13.43)	83.75 (69.50-119) 86.80±16.09	-18.11	0.003b

Statistical significance $p<0.005$; D: difference; a:student's t test with mean ± standard deviation; b:Mann Whitney U test with median (min-max) (mean ± standard deviation).

Table 3. The fifty-meter swimming competition times for four-swimming styles, according to the genders

Style	Girls	Boys	D (%)	p
Freestyle (s)	29.48±2.35	27.05±2.32	-8.24	0.009a
Backstroke (s)	32.18±2.79	30.96±2.33	-15.94	0.231a
Breaststroke (s)	36.19±2.92	32.92±2.19	-9.03	<0.001a
Butterfly (s)	32.44±3.49	29.79±2.53	-8.16	0.014a

Statistical significance p<0.05; D: difference; s: second; a:student's t test with mean±standard deviation.

Table 4. The correlation between right, and left ankle flexion and fifty-meter swimming times, according to the genders.

Gender	Variables - ankle		Freestyle	Backstroke	Breaststroke	Butterfly
G	**Dorsiflexion, right (°)**	**r**	**-0.610****	**-0.609****	**-0.623****	**-0.577****
		p	**0.004a**	**0.004a**	**0.003a**	**0.008a**
G	**Planter flexion, right (°)**	**r**	**-0.621****	**-0.548***	**-0.582****	**-0.561***
		p	**0.003a**	**0.012a**	**0.007a**	**0.010a**
G	**Dorsiflexion, left (°)**	**r**	**-0.820****	**-0.849****	**-0.746****	**-0.842****
		p	**<0.001b**	**<0.001b**	**<0.001b**	**<0.001b**
G	**Planter flexion, left (°)**	**r**	**-0.716****	**-0.628****	**-0.631****	**-0.655****
		p	**<0.001a**	**0.003a**	**0.003a**	**0.002a**
G	**Dorsiflexion average (°)**	**r**	**-0.737****	**-0.783****	**-0.720****	**-0.745****
		p	**<0.001b**	**<0.001b**	**<0.001b**	**<0.001b**
G	**Planter flexion average (°)**	**r**	**-0.665****	**-0.590****	**-0.607****	**-0.593****
		p	**0.001a**	**0.006a**	**0.005a**	**0.006a**
B	**Dorsiflexion right (°)**	**r**	-0.347	-0.113	-0.163	-0.152
		p	0.134a	0.635a	0.493a	0.523a
B	**Planter flexion, right(°)**	**r**	-0.418	-0.085	-0.201	-0.288
		p	0.058a	0.721a	0.396a	0.218a
B	**Dorsiflexion, left (°)**	**r**	**-0.560***	**-0.460***	**-0.505***	**-0.582****
		p	**0.010a**	**0.041a**	**0.023a**	**0.007a**
B	**Planter flexion left (°)**	**r**	-0.381	-0.126	-0.243	-0.239
		p	0.097b	0.597b	0.303b	0.310b
B	**Dorsi flexion average (°)**	**r**	**-0.540***	**-0.468***	**-0.495***	**-0.526***
		p	**0.014a**	**0.048a**	**0.026a**	**0.017a**
B	**Planter flexion average (°)**	**r**	-0.387	-0.035	-0.159	-0.221
		p	0.092b	0.885b	0.504b	0.348b

Statistical significance p<0.001**; G: Girls; B: Boys; a: Pearson correlation coefficient b:Spearman correlation coefficient.

DISCUSSION

To the best of our knowledge, the researches related to ankle joint flexibility about swimmers has been evaluated on a specific swimming style or technic. Therefore, this is the first study to investigate the relationship related to ankle joint flexibility and 50 m swimming performance based on four swimming styles for both genders. The study aimed to determine the relationship of plantar flexion and dorsiflexion range of motion on swimming performance based on genders in four swimming styles. This study primary findings respectively: (a) girl swimmers had the significantly greater right, left, and average ankle plantarflexion angles than boy swimmers (Table 2); (b) left and average ankle dorsiflexion negatively as high level correlated with swimming time on four swimming styles, but right ankle dorsiflexion negatively correlated as moderate level in girl swimmers; (c) right, left and average ankle plantar flexion negatively as moderate level correlated with swimming time on four swimming styles in girl swimmers; however, in boy swimmers, (d) left, and average ankle dorsiflexion negatively as moderate level correlated with swimming time for all styles; (e) right, left and average ankle plantar flexion, and right ankle dorsiflexion was not significantly correlated with swimming time for all styles.

When boys access the biological maturation of the girls in puberty become taller, heavier, with more muscle strength, as well as presenting better motor control and coordination (3). In our study, the similar results were seen between the genders, as

based on these findings, the reason for the differences between the swimming time for both genders may be explained because of the fact that the differences, including tall, body mass, Fat %, and FFM (Table 1). Besides, the differences to the right-left, and average ankle plantarflexion angles between the genders (Table 2), may be explained by girls had more flexible joint structure or a higher range of motion dependent on the higher body fat percent generally in girls than boys (Table 1) Baechle and Earle (2).

The present study findings indicated that a significant relationship in high and moderate level between ankle plantar and dorsiflexion (right and left) and swimming time for all styles in girls (Table 4). However, in boy swimmers only left, and average ankle dorsiflexion correlated moderately with swimming time for all styles. Our study findings may also indicate that the reason for the differences that occurred in correlation analysis for the right and left ankle joint angles (plantar and dorsiflexion), could be caused because of the fact that using a dominant body limb or the gender differences which girl swimmers had greater ankle flexibility. The literature studies mostly investigated to the specific style or technical perspective, but the findings that partly agreement with our results showed that McCullough et al. (10) reported being a significant relationship between ankle plantar flexion and 50 m swimming times in the competitive swimmers. They stated that the greater flexibility in the ankle was able to flutter kick with greater velocity for the swimmers. Jagomägi and Jürimäe (8) stated that flexibility measurements that consist of knee external rotation, ankle supination, and hip external rotation, explained swimming results 28.2 %. In addition, they stated that good flexibility was more important than a single anthropometrical parameter to explain breaststroke swimming results. Shimojo et al. (22) reported that foot rotational flexibility, rather than ankle plantar flexibility, is associated with an increase in butterfly kick velocity. Sugimoto et al. (20) found that swimmers with low flexibility of plantar flexion tended to achieve a faster swimming velocity after increasing the plantar flexion angle. Willems et al. (24) reported that between ankle muscle strength and dolphin kick performance was significantly correlated. They also stated that a flexibility restriction in plantar flexion and internal rotation in the ankles showed a significant decrease in dolphin kick performance in competitive swimmers. They also recommended that enhancing dolphin kick velocity might be provided by ankle muscle strength exercises and restricted ankle flexibility might improve by a flexibility program. The findings of our research support these statements. In contrast to these studies, Mookerjee et al. (13) found that there was no significant relationship between ankle plantar and dorsiflexion and swimming performance. Reichmuth et al. (18) stated that the flexibility measurements that included shoulder inside rotation, shoulder outside rotation, hip extension, sit-and-reach, plantar flexion, supination showed no significant correlation with race time of any of the lifesaving disciplines. Geladas et. al. (6) reported that the girl swimmers significantly had a larger ankle flexibility angle than the boys, but for both genders, ankle flexibility was not correlated with 100 m freestyle swimming. However, they demonstrated that for both genders respectively, body height, upper extremity and hand length, shoulder flexibility, and horizontal jump were related significantly with swimming performance in girls; body height and mass, arm, hand, and foot length, chest circumference, biacromial and biiliac breadths significantly correlated with swimming performance in boys. Some of literature findings and our study findings partly may suggest that ankle joint flexibility may be a potential contributor to the swimming time for both genders, especially girl swimmers.

The literature studies suggest that improve performance in swimming for both the styles and gender may have been related to increased aerobic, anaerobic (4, 12, 26), muscle strength and endurance (6, 9, 14), flexibility (19), speed (7, 26, 25), agility (27), and balance (16) components. Success in sports is a multifaceted phenomenon including many interrelated conditions. Therefore, swimming performance not only a single variable requires but also needs performance components which aforementioned, however, more specific components such as ankle flexibility, may be willing to importance to reach a high level of performance. McCullough et al. (10) asserted that on the biomechanical side, the foot is positioned to remove water in a backward direction provided that the ankle has the larger angles to plantar flex. This condition may be supporting to push the water backward, at the same time, it would provide propulsion to move the body forward in swimming.

CONCLUSIONS

It is evident that minor details in sports are decisive in achieving success in many events. Therefore, these findings highlight the potential importance of ankle plantar and dorsiflexion on swimming 50 m time particularly in girl swimmers. If the specific training practices may be used to improve ankle joint flexibility in water or dry-land training, it could contribute to swimming performance for both genders.

Disclosure Statement

The authors report no declarations of interest.

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