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A Study on The Effects of the Absence of Palmaris Longus Tendon on Handgrip Strength of Athletes

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Abstract: *The study aims to find out the incidence of the absence of palmaris longus tendon and to study the effects of the case on handgrip strength of athletes. We studied whether 190 athletes (male n= 80, mean age: 18.9± 2.2; female n= 110, mean age: 18.5± 1.2) included in our study had palmaris longus tendon or not. Then, the handgrip strength values of the athletes were obtained by using a Jamar dynamometer, according to the recommendations of the American Association of Hand Therapists. Total number of participants having no palmaris longus tendon was 59 (31.05%) and it was observed that 37(19.47%) of these individuals didn't have the tendon in both hands. The number of participants with unilateral tendon absence was 22 (11.5%). The tendon was absent in right hand of 10 individuals (5.26%) and in left hand of 12 individuals (6.31%). After controlling age, height, body weight and body mass index variables of the groups, it was observed that the presence or the absence of palmaris longus tendon in both hands of male athletes didn't cause any statistical effects on handgrip strength of the athletes. However, left handgrip strength of female athletes with palmaris longus tendon in left hand was found to be higher than left handgrip strength of female athletes with no palmaris longus tendon (p<.01). According to the findings of the study, we might state that the presence or the absence of palmaris longus tendon does not cause a significant effect on handgrip strength of both hands of male athletes (p>.05) and that its presence causes a significant effect on left handgrip strength of female athletes (p<.01).*

Keywords*: absence of palmaris longus tendon, handgrip strength, dynamometer.*

1. Introduction

The muscle of palmaris longus originates from medial epicondyle and as a long and thin tendinous structure, it passes over the anterior transverse ligament and inserts into palmar aponeurosis [1]. The muscle stretches aponeurosis palmaris and enables the flexion of hands and helps forearm flexion [2]. Palmaris longus tendon (PL) has frequently been used as a tendon graft in many surgical operations: for interposition for Kienböck's disease [3, 4]; for chronic tendon injury [5]; for chronic lateral ankle instability and ulnar collateral ligament reconstruction of the elbow [6, 7]; and for other reconstructive surgeries. To augment tendon repair, various biological and non-biological materials have been considered to be useful and the mostly examined are tissue grafts, synthetic fibers, biological fibers, and tissue engineered biomaterials [8]. Especially for tendon and ligament tissue engineering, fibre-based scaffolds have been widely used and knitted scaffolds have been proved to be good for collagenous matrix deposition that is crucial for tendon and ligament reconstruction [9].

The absence of PL in different populations has been studied by some researchers and it has been stated that the absence of the tendon might be caused by ethnical differences. The incidence of the absence was reported to be 10% in Chinese, 9% in Malays, 3% in Indians [10], 1.02% in Ugandans [11], 1.5% in Zimbabweans [12], and 63.9% in Turkish [13], the highest incidence among different nations. In addition, it was reported in some studies that neither the absence nor the presence of PL doesn't cause an effect on handgrip strength (HGS) of individuals [8], however, some other studies in

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literature reported that the absence of the tendon causes adverse effects on the handgrip strength of individuals in others [14].

This study aims to detect the absence or the presence of the PL tendon of male and female athletes and to find out the effects of the case on handgrip strength of both hands of the athletes.

2. Materials and methods

The study was approved by Clinical Ethics Committee, Meram Medical Faculty, the University of Necmettin Erbakan (approval number: 2020/2308). The study included 190 individuals doing team or individual sports (80 males, 110 females, 380 hands in total). Table 1 shows demographic characteristics of the groups.

Table 1. Morphometric body measurements and age of the participants in the study

Groups	Characteristics	Min.	Max.	Mean	Std. Deviation
Male (n= 80)	Age (years)	18	30	18.91	2.29
	Height (m)	1.57	1.92	1.740	.07
	BW (kg)	53.0	123.0	73.98	15.65
	BMI (kg/m^2)	17.83	35.55	24.34	4.50
Female (n= 110)	Age (years)	18	27	18.59	1.28
	Height (m)	1.51	1.85	1.63	.05
	BW (kg)	39.0	87.0	55.27	8.87
	BMI (kg/m^2)	15.23	29.40	20.60	3.01

BW: Body weight, BMI: Body muscle index

Only one athlete in male groups and 2 athletes in female groups were left-handed dominantly. Participants under 18, having locking and catching in finger and hand movements, suffering from rheumatoid arthritis, possessing the history of an injury or a disease or abnormality of the upper limb, which would preclude examination for the presence of the PL tendon, and having difficulty in using hands or having hand weakness owing to a trauma or an operation were excluded in the study. For the presence of the PL tendon, the following tests were used: Schaeffer's [15], Thompson's [16], Mishra's [17], Pushpakumar's [18]. In the case that any one of these tests proves the presence of the PL tendon, we accept that the tendon is present, even if the PL tendon is not detected by other tests and in order to decide whether the PL tendon is absent, the tendon needs to be non-palpable and non-visible in all of the tests mentioned. HGS was measured using a calibrated Jamar dynamometer (Asirnow Engineering Co, Los Angeles, CA, USA) at level 2 in a standardized position, as described by the American Association of Hand Therapists [19]. All measurements were made in this standardized position which means shoulders are at adduction, elbows are flexed at 90 degrees and arms and wrists are at neutral position. While carrying out the tests, the participants were told to use maximal power. For each strength test the scores of three successive trials were recorded for each hand. The highest HGS value for each hand was used for analysis. The trials for each measurement were made after a rest of at least one minute to minimize fatigue. The HGS values obtained were recorded in kg. For the analysis of the data, SPPS 25 (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.) statistical packaged software was used. Before basic analysis, descriptive statistical values regarding demographic characteristics were studied. To figure out whether HGS values vary in male and female groups, t-Test was carried out in independent groups. Moreover, ANCOVA was used so as to find out whether HGS values vary depending on the presence or the absence of the PL tendon and to analyze the effects of variables of age, height, body weight (BW) and body mass index (BMI) on HGS values.

3. Results and discussions

The PL tendon was absent unilaterally in 22 participants (11.5%), while it was absent bilaterally in 37 (19.47%). The total incidence of the absence of the PL tendon (unilateral or bilateral) was 31.05% (59 participants). Among males, the PL tendon was absent on the right side in 5 participants (6.25%) and on the left side in 4 participants (%5) and was absent bilaterally in 16 (20%). Among females, the PL tendon was absent on the right side in 5 participants (4.54%) and on the left side in 8 participants (7.27%) and was absent bilaterally in 21 participants (19.09%). The total incidence of PL absence (unilateral or bilateral) was 31.25% in males (25 participants) and 30.9% in females (34 participants) (Table 2). We also keep the opinion that the different sports that the athletes in the study were performing may have influenced hand grip strength individually.

Table 2 shows the PL tendon absence of athlete groups (right, left, bilateral and unilateral).

Table 2. The incidence of the absence of the PL tendon in males and females.

Absence of PL	Right hand	Left hand	Bilateral	Overall
Male	5 (6.25%)	4 (%5)	16 (20%)	25 (31.25%)
Female	5 (4.54%)	8 (7.27%)	21 (19.09%)	34 (30.9%)
Total	10 (5.26%)	12 (6.31%)	37 (19.47%)	59 (31.05%)

PL: Palmaris longus tendon

Table 3 shows the differences in right and left HGS values of male and female athletes. From the analyses to study whether right and left HGS values of the groups vary significantly (t-Test for independent groups), it was observed that both right and left HGS values of male groups were higher than HGS values of female groups, the findings were as follows, respectively: t(103,434) = -11.24, p<.001, t(108,799) = -11.62, p<.001 (Table 3).

Table 3. The comparison of right and left HGS values of male and female athletes.

HGS	Gender	Mean	Std. Deviation	*t*	95% Confidence Interval of the Difference	
					Lower	Upper
Right HGS (kg)	Male(n=80)	47.46	13.09	-11.24***	-21.36	-15.13
	Female(n=110)	29.79	6.02			
Left HGS (kg)	Male (n=80)	47.11	12.88	-11.61***	-20.79	-14.55
	Female (n=110)	28.86	6.56			

HGS: Handgrip strength

From the view that the differences result from gender, male and female athletes were assessed independently in analyses of comparison. Furthermore, in comparison analysis of HGS values of athletes with and without the PL tendon, possible effects of age, height, BW and BMI variables were controlled (Table 4).

When the findings of the study were assessed, it was observed that age, height, BW and BMI didn't have a significant predictor effect on both right and left HGS values of male athletes. Also, when the same variables were controlled, it was found out that the presence or the absence of the PL tendon did not cause a significant effect on HGS values (Table 4).

It was observed that in females, age, height, BW and BMI were significant predictors of right HGS values. When the effect of the variables was controlled, it was seen that the presence or the absence of the PL tendon did not cause a significant difference in right HGS values (Table 4). Moreover, it was also found that age was a significant predictor for left HGS values of female athletes. When the effect of the variable was controlled, it was seen that the presence or the absence of the PL tendon caused a significant difference in left HGS values (F (1, 220.72) = 7.30, p<.01. (Table 4).

Table 4. HGS value comparisons of the groups.

Gender	Source	df	Right HGS (kg) Mean Square	F	Sig.	Partial Eta Squared	Left HGS (kg) Mean Square	F	Sig.	Partial Eta Squared
Male	Height (m)	1	31.89	.25	.61	.003	34.49	.27	.59	.004
	BW (kg)	1	47.58	.38	.53	.005	43.75	.35	.55	.005
	BMI (kg/m^2)	1	10.20	.08	.77	.001	10.17	.08	.77	.001
	Age	1	434.31	3.51	.06	.045	474.18	3.83	.05	.049
	PL	1	13.55	.11	.74	.001	.25	.002	.96	.000
Female	Height (m)	1	147.14	6.53*	**.012**	.059	22.76	.753	.38	.007
	BW (kg)	1	214.44	9.51**	**.003**	.084	51.75	1.71	.19	.016
	BMI (kg/m^2)	1	156.35	6.94*	**.010**	.063	27.01	.89	.34	.009
	Age	1	191.83	8.51**	**.004**	.076	311.75	10.30**	**.002**	.090
	PL	1	49.68	2.20	.141	.021	220.72	7.29**	**.008**	.066

BW: Body weight, BMI: Body muscle index, HGS: Handgrip strength, PL: Palmaris longus tendon

According to the findings of the study, it was found that the presence or the absence of the PL tendon in both hands didn't cause any significant effects on HGS values of the male athletes. However, the presence of left PL tendon had a significant effect on left HGS values of the female athletes (Table 5).

Table 5. Mean and estimated marginal mean of right and left HGS

HGS	Gender	PL	n	Mean HGS	Std. Deviation	Estimated Marginal Mean	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound	p
Right Hand	Male	Absent	21	47.90	16.54	48.15	43.30	53.00	.74
		Present	59	47.31	11.78	47.21	44.32	50.10	
	Female	Absent	26	28.19	5.90	28.51	26.58	30.44	.14
		Present	84	30.29	6.00	30.18	29.14	31.22	
Left Hand	Male	Absent	20	46.90	15.48	47.01	42.03	51.99	.96
		Present	60	47.18	12.05	47.14	44.27	50.01	
	Female	Absent	29	26.52	6.02	26.40	24.32	28.48	**.01**
		Present	81	29.70	6.57	29.74	28.51	30.96	

HGS: Handgrip strength, PL: Palmaris longus tendon

Tendons and ligaments are dense collagenous connective tissues. These tissues join bones to muscles and bones to bones, respectively. Injuries of these tissues are among the most common injuries to the body and are particularly more common in the young and physically active individuals. [20, 21]. Though medications including autografts, allografts and prosthetic grafts are widely used in the injuries of these collagenous connective tissues, the management of these medications have important limitations. In tissue engineering, conservative management is associated with a higher level of re-rupture, surgical management with tendon autografts, however, such treatments are associated with complications such as repair-rupture, adhesions and stiffness, reduced strength and donor-site morbidity. Tissue engineering is good in treating these conditions by replacing the injured tissue with an engineered tissue with similar mechanical and functional properties [22, 23].

In their study, [9] focused on different methods for tissue engineering and they compared the improvement of different materials with different characteristics. Their objective was to develop three types of hybrid scaffolds from knitted meshes and evaluate them for improvement in their mechanical and biological properties. These scaffolds were made by coating the knitted scaffolds by various methods: using a thin film of a biodegradable polymer, poly (ε-caprolactone) (PCL); using nanofibres of poly (D,L-lactide-co-glycolide) (PLGA) and using a film of a natural biopolymer, collagen type I. From their study findings, they concluded that knitted scaffolds could sustain cell growth and proliferation better than woven scaffolds. Knitted poly (L-lactic acid) scaffolds showed a better mechanical and degradation profile than poly(D,L-lactic acid-co-glycolic acid) scaffolds. The hybrid scaffolds possessed good mechanical properties and could be easily seeded with cells. The modification techniques of coating with nanofibres or collagen were particularly effective in aiding cell attachment, growth and proliferation. Such hybrid scaffolds have great potential in tissue engineering of tendons/ligaments. In a study, silicone implant replacement and palmaris longus tendon replacement medications were used for 32 patients with Kienbock's disease, the authors declared that in the early stages of carpal collapse, both arthroplasties yielded good results and the silicone implant replacement was more effective in the prevention of further carpal collapse than the palmaris longus tendon [24].

Palmaris longus, extensor indicis proprius, extensor digiti minimi, plantaris tendon along with hallux extensor are generally used as tendon graft in various reconstructive medications of hand. Palmaris longus is known to be one of the most variable muscles in humans. The absence seems to be hereditary, however, the effect of genetic transmission is not totally clear [25]. The incidence of congenital absence of the PL muscle was first reported in 1944 by Reimann et al. [26] as 15% in the general population. In our study on the presence of the PL tendon in male and female athlete groups, we found that 19.47% of the athletes had bilateral absence and 15% had unilateral absence of the PL tendon.

Ertem et al. (2007) [27] studied the effects of the presence or absence of the PL tendon on pinch and HGS values of healthy males and declared that the incidence of the absence of the tendon was 34%. The same researchers also reported that the PL tendon was bilaterally absent in both hands of 22.5% of the participants, only in right hand of 28.2%, only in left hand of 28.2% and it was absent unilaterally in 11.52% of the participants. Furthermore, Ertem et al. (2007) [27] declared that they found right and left HGS values of individuals with the PL tendon were 47.4±7.6 kg and 46.6±7.5 kg, respectively. They also declared that right and left HGS values of individuals with no PL tendon were 46.7±7.0 kg and 45.7±7.4 kg, respectively. They noted that right and left HGS values of the individuals with the PL tendon were quantitatively higher than right and left HGS values of the individuals having no PL tendon, however, they didn't notice any statistically significant differences in right and left HGS values of the individuals with or without PL tendon ($p>0.05$). Ertem et al. (2007) [27] reported that the absence of the PL tendon found in their study was more incident than the findings of former studies on PL, in addition, they stated that the use of the PL tendon in reconstructive hand surgeries would not cause a significant lose in HGS values.

Koç et al. (2011) [14] studied the effects of the presence or the absence of the palmaris longus tendon on HGS values of male and female individuals doing sports and declared that the PL tendon was absent in a total of 24 individuals, 12 males and 12 females. The researchers reported the HGS values of males and females with PL were 49.91±5.57 kg and 29.35±4.52 kg, respectively. They also noted that the HGS values of males and females with no PL were 42.66±5.77 kg and 23.41±4.83 kg, respectively. Koç et al. (2011) [14] reported that the HGS values of both male and female individuals with PL were higher than the HGS values of individuals with no PL ($p<0.001$). From the findings of their study, they stated that the presence of PL, which plays an important role in sports activities, might positively affect HGS values.

Sebastin et al. (2005) [10] studied the absence of the PL tendon of males and females (n= 418 subjects; aged between 7 and 85 years with a mean age of 42 years, SD 16) from China (10%), Malaysia (9%), India (3%) and other nations and tried to find out the effects of the case on HGS values and pinch force of the individuals. They reported that the tendon was unilaterally absent in 17 (4%) and bilaterally absent in 7 (2%) individuals and that the general incidence of the absence of the PL (unilateral and bilateral) tendon was 6% (95% CI 4-8). In addition, Sebastin et al. (2005) [10] reported that they found the mean HGS of the right hand was 30±10 kg (Median: 28; Range: 6–63 kg), while the mean HGS of the left hand was 28±10 kg (Median: 26; Range: 5–64 kg) and stated that there was no significant difference in the HGS and pinch force values between individuals with or without PL in both hands.

Cetin et al. (2013) [28] studied pediatric individuals and reported that in the right hand, the incidence of the absence of the PL tendon was 25.9% in males, 35.4% in females, and an overall average of 30.4%, while in the left hand, the incidence of the absence of the PL tendon was 27.9% in males, 37.5% in females, and an overall average of 32.5%. Moreover, they stated that they found no significant differences in HGS values of males and females with or without the PL tendon. Furthermore, Cetin et al. (2013) [28] noted the individuals without the PL tendon had no complaints to maintain daily activities. As a result, they noted that using PL for a reconstructive surgery of any pathology may not result in any important functional disorder of the hand.

From the ultrasound images of healthy male and female individuals (30 males and 34 males, aged 18-22), Karahan et al (2017) [29] studied the presence or the absence of the PL tendon and they reported the tendon was present in right hand of 73.3% of males and 55.9% of females. Moreover, they also found the wrist extension force of male groups with PL tendon was 31.65±9.15 N for the right hand and 28.54±8.52 N for the left hand, whereas the wrist extension force of males without the tendon was 31.36±10.75 N for the right hand and 27.76±9.05 N for the left hand. In female groups, the wrist extension force of the hand with PL tendon was 17.13±7.07 N for the right and 14.68±6.57 N for the left, whereas it was 16.67±7.07 N for the right hand and 15.07±8.02 for the left hand of females with no PL tendon. From the findings, Karahan et al (2017) [29] reported that the presence or the absence of the PL tendon in both hands of both genders does not have any statistical effects on the wrist flexion and wrist extension force of the individuals ($p>0.05$).

In order to find out the incidence of the absence of the PL tendon in Turkish population, Irmak et al. (2017) [30] included males and females (mean age 18-66, 533 participants, 1066 hands) in their study and they reported the incidence of the tendon in general population was 21.8%. They also reported that the PL tendon absence in females (22.3%) was higher than in males (21.3%) and bilateral PL tendon absence (82 individuals, 15.4%) was higher than unilateral PL tendon absence (34 individuals, 6.3%). Irmak et al. (2017) [30] also stated that bilateral absence of the PL tendon was significantly higher than unilateral absence of the PL tendon ($p<0.05$).

In their study on which Kose et al. (2008) [31] studied the absence of the PL tendon in Turkish individuals (675 males and 675 females;18 and 85 mean age 38.4; SD: 14.7), they reported the general absence (bilateral and unilateral) of the tendon was 26.6%. They also stated that they observed the absence of the PL tendon was statistically more common in females than in males. They also noted that the rate of bilateral absence of the tendon was statistically higher than the rate of its unilateral absence and the incidence of the tendon absence on both hands was also at the same level in many individuals. In a study on the absence of the PL tendon of healthy males and females (150 males, 150 females, mean age 18-40), the researchers reported that the tendon was bilaterally absent in 9% and unilaterally absent in 16% of the individuals [32]. In a study on the presence or the absence of the PL tendon of 800 African individuals (1600 hands), the incidence of the absence in general population was reported to be 1.8% (34 individuals) [33]. Alzahran et al. (2017) [34] studied the presence or the absence of the PL tendon of 331 volunteer young individuals from Saudi Arabia (164 males, 167 females, mean age 23), and they stated that the tendon was bilaterally absent in 15.1% (50 individuals), absent in right hand in 15.3% (45 individuals) and absent in left hand in 3.5% (5 individuals) of the individuals. The absence of the PL tendon in right and left hands of the participants in our study was found to be 6.25% and 5% in males, and 4.54% and 7.27% in females, respectively. It was observed that the tendon was bilaterally absent in 19.47% (37 individuals). The tendon was bilaterally and unilaterally absent in 25 males (31.25%) and in 34 females (30.9%). It was also observed that the tendon was bilaterally and unilaterally absent in 59 individuals in total in both groups (31.05%).

From the findings of our study, we observed that the results of the studies on the absence of the tendon in different nations carried out by Sebastin et al. (2005) [10], Thompson et al. (2002) [32], Kigera et al. (2013) [33], Alzahran et al.(2017) [34], Igbigbi et al. (1998) [11] and Gangata, (2009)

[12] were lower than the absence rate of the tendon in our study. We are of the opinion that the differences might be caused by national differences. The studies on the absence of the tendon in Turkish population, the reported rate of the absence by the researchers was 34% [27], 21.8% [30], 26.59% [31], 32.5% [28]. The rate of total PL tendon absence in our study was lower than the study of Ertem et al. (2007) [27], higher than the studies of Irmak et al. (2017) [30] and Kose et al. (2008) [31] and almost the same with the study of Cetin et al. (2013) [28]. Additionally, Ertem et al. (2007) [27], Sebastin et al. (2005) [10], Cetin et al. (2013) [28] and Karahan et al (2017) [29] reported in their studies that the presence or the absence of the PL tendon does not have any effects on the handgrip strength of the participants. In our study on male and female athlete groups, it was also found that the presence or the absence of the PL tendon on both hands of male athletes and only on right hands of female athletes doesn't affect handgrip strength of the individuals. Koç et al. (2011) [14] reported that the HGS values of male and female athletes with the PL tendon were higher than the HGS values of the athletes without the tendon. In the group of female athletes in our study, it was observed that the HGS values of the participants with left hand PL tendon were higher than the HGS values of the participants with no left hand PL tendon.

There were some limitations in this study. The main limitation was that the study was limited to the athletes living in Konya, Turkey, thus, the number of the participants was limited. Furthermore, as radiological imaging methods are costly, the assessment of the presence or the absence of the tendon was carried out by different methods defined in literature.

4. Conclusions

Consequently, it might be stated that the presence or the absence of the palmaris longus tendon in male athletes doesn't have any effects on the handgrip strength and that the presence of the palmaris longus tendon in left hands of female athletes might have a significant effect on the handgrip strength. Furthermore, we consider that future studies with a larger number of athletes and by radiological images to find out the presence of the tendon might be beneficial for the assessment of the effects of the presence or the absence of the tendon on athletic performance.

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