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The Neuromuscular Profile of Knee Extensor and Flexor Muscles in Professional Soccer Players in The Saudi Premier League

El perfil neuromuscular de los músculos extensores y flexores de rodilla en jugadores de fútbol profesionales en la Arabia Premier League

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ABSTRACT

Purpose: The neuromuscular system of soccer players is a key factor in their competitive performance, as it determines a player's immediate force response, reactivity and running speed during matches. The neuromuscular system has recently begun to be analyzed by tensiomyography (TMG). This study's primary aim was to generate normative data of the mechanical and neuromuscular profile for the knee extensor and flexor muscles.

Method: This study used a cross-sectional study of 83 professional soccer players from three Saudi Premier League teams at the start of the preseason period. TMG was used to measure the radial muscle belly displacement in the knee extensor and flexor muscles in both legs.

Results: The results suggest that the highest degree of symmetry corresponded to the vastus medialis (83.7 ± 14.3%) and the lowest to the biceps femoris (76.1 ± 10.9%). No statistical difference was found between the dominant and non-dominant muscles, or between on-field player positions across all four tested muscles.

Conclusion: The study presented normative data of a convenience sample of Saudi professional soccer players and observed that the highest asymmetry was seen in the vastus medialis and the lowest asymmetry in the biceps femoris.

KEYWORDS

Football players; Tensiomyography; Preseason testing; Normative

RESUMEN

Propósito: El sistema neuromuscular de los jugadores de fútbol es un factor clave en su desempeño competitivo, ya que determina la respuesta de fuerza inmediata de un jugador, la reactividad y la velocidad de carrera durante los partidos. Recientemente se ha comenzado a analizar el sistema neuromuscular mediante tensiomiografía (TMG). El objetivo principal de este estudio fue generar datos normativos del perfil mecánico y neuromuscular de los músculos extensores y flexores de la rodilla.

Método: Este estudio utilizó un estudio transversal de 83 futbolistas profesionales de tres equipos de la Liga Premier de Arabia Saudita al comienzo del período de pretemporada. La TMG se utilizó para medir el desplazamiento del vientre del músculo radial en los músculos extensores y flexores de la rodilla en ambas piernas.

Resultados: Los resultados sugieren que el mayor grado de simetría correspondió al vasto medial (83,7 ± 14,3%) y el menor al bíceps femoral (76,1 ± 10,9%). No se encontraron diferencias estadísticas entre los músculos dominantes y no dominantes, o entre las posiciones del jugador en el campo en los cuatro músculos evaluados.

Conclusión: El estudio presentó datos normativos de una muestra de conveniencia de futbolistas profesionales sauditas y observó que la mayor asimetría se observó en el vasto interno y la menor asimetría en el bíceps femoral.

PALABRAS CLAVE

Futbolistas; Tensiomiografía; Pruebas de Pretemporada; Normativa

1. INTRODUCTION

The integrity of the neuromuscular system is crucial to control key performance characteristics such as running speed, reactivity and immediate force response for any athlete (García-García et al., 2017). Tensiomyography (TMG) is a non-invasive, simple assessment tool for detecting skeletal muscle contractile properties. TMG measures radial muscle belly displacement, induced by electrical stimulation, during an isometric twitch contraction. It can be used to detect impaired neuromuscular properties, muscle imbalances and lateral imbalance (Lohr et al., 2019; Macgregor et al., 2018). The five main contractile parameters measured with TMG are maximal displacement (D_m), delay time

(T_d), contraction time (T_c), half relaxation time (T_r), and sustain time (T_s) (García-García et al., 2017; Macgregor et al., 2018; Seidl et al., 2017; Valenčič & Knez, 1997)

TMG is easy to use, as it is a portable machine, and provides reliable data of isometric muscle contraction (Martín-Rodríguez et al., 2017). Although TMG uses superficial electrodes, no differences were reported between the laser sensor and contact sensor as both showed excellent reliability (Caldwell & Peters, 2009). Since previous publications have demonstrated that neuromuscular testing is affected by fatigue (Caldwell & Peters, 2009; Ditroilo et al., 2013; García-García et al., 2017; Mohr et al., 2005; Nedelec et al., 2014), it is suggested that baseline measures of neuromuscular function should be taken at the beginning of the season.

In a cross-sectional study, García-García et al. 2017 used TMG to investigate the neuromuscular profile of 16 football players. They found no difference between the dominant and non-dominant legs. The player's on-field position affected some parameters, especially the Tr of biceps femoris (BF) and the sustained force of vastus medialis (VM). This variation in neuromuscular profile was similar to results reported by Di Salvo et al.2007 . However, this study examined the players during the season, so fatigue may have influenced the results.

Differences in style, culture and physical performance between professional players are evident even in top-ranked professional leagues (Yi et al., 2019). Thus, there is a need to provide reference values that can be used for comparison and to help clinicians and trainers determine training needs. Therefore, the primary aim of this study was to measure the neuromuscular profile of knee extensor and flexor muscles in a convenience sample of professional soccer players in the Saudi Premier League. The secondary aim of the study was to examine differences between the dominant and non-dominant sides and between players' on-field positions.

2. METHODS

2.1.Design

A cross-sectional study was undertaken.

2.2. Setting and participants

The study was conducted in a specialized sports rehabilitation center in Riyadh, Saudi Arabia. Eighty-three players from three Saudi Premier League teams that approached the center for preseason testing were included. All players were healthy and reported no injuries. All participants provided written informed consent. No specific ethics clearance was sought as these measurements were considered part of the usual preseason testing regimen.

2.3.Outcome measures

Measurements were taken at the beginning of preseason testing (i.e., before players underwent any training or other testing procedures) by one of two assessors, who had more than two years of experience in preseason testing. TMG testing was undertaken using the TMG ™-S2 machine.

TMG was undertaken using the testing protocol reported by García-García et al. 2017 and involved four knee extensor and flexor muscles: the rectus femoris (RF), Biceps femoris (BF), Vastus medialis (VM), and vastus lateralis (VL).

For this study, the following variables were used to describe the functional involuntary contractile property of the examined muscle. Times were expressed in ms and displacement in mm.

1. Time of contraction (T_c) represents the time taken between 10% and 90% of the maximum vertical muscle movement.
2. Sustain time (T_s) represents the time from 50% of the muscle contraction to 50% of its relaxation.
3. Relaxation time (T_r) represents the time required to reduce the muscle contraction, after an electrical stimulus, from 90% to 50% of the overall maximum muscle belly displacement.
4. Delay time (T_d) is the time required to reach 10% of the maximum muscle belly displacement.
5. Maximal displacement (D_m) represents the overall displacement (shortening) of the muscle by an involuntary stimulation.
6. Lateral asymmetry, which involved comparing the superficial muscles' contractile properties between the right and left side.

2.4.Data analyses

Data were analyzed to obtain the mean ± SD of each parameter tested. Paired t-tests were used to compare dominant and non-dominant leg muscle TMG, and significance was set at $p < 0.05$. Each participant's on-field position was used as an independent factor to calculate the difference in the asymmetry of each of the four tested muscles (dependent variable) using variance tests.

3. RESULTS

The neuromuscular assessment was obtained from (n=83) players from different positions in the field. Table 1 highlight the study characteristics.

Table 1. Demographic and descriptive data for the 83 participants	
Age, years, mean (SD)	24.9 (4.1)
Height, cm, mean (SD)	175.3 (13.3)
Weight, kg, mean (SD)	70.5 (9.1)
On-field position, n (%)	
Defender	40 (48.2)
Midfielder	18 (21.7)
Forward	15 (18.1)
Goalkeeper	10 (12.1)

3.1. TMG data

As summarized in Table 2, there was considerable variability between participants in TMG data - mainly in terms of T_s and T_r as is evident from the large SD values. The highest asymmetry was observed in the VL and the lowest in the BF.

Table 2. TMG data

TMG variable	Rectus femoris	Vastus medialis	Vastus lateralis	Biceps femoris
Time of contraction, ms ± SD	30.5 (7.1)	24.7 (6.3)	25.3 (7.4)	31.7 (12.5)
Sustain time, ms ± SD	85.4 (53.3)	110.2 (62.4)	171.2 (37.5)	179.5 (58.7)
Relaxation time, ms ± SD	49.5 (42.1)	64.5 (46.7)	73.3 (51.1)	63.7 (34.2)
Delay time, ms ± SD	5.1 (4.0)	22.2 (2.7)	24.9 (4.9)	23.7 (4.4)
Maximal displacement, mm ± SD	6.3 (2.7)	4.7 (1.8)	6.9 (2.1)	4.5 (3.2)
Lateral asymmetry ± SD	80.0 (11.1)	81.4 (9.2)	84.2 (10.2)	77.8 (12.2)

Paired t-tests to compare TMG data between the dominant and non-dominant muscle groups revealed no statistical difference across all four muscles, except in RF Dm and VL Td, t (83) = -2.15, p = 0.03; t (83) =-3.47, p = 0.001, respectively. (Table 3).

Table 3. Paired sample t-test comparing dominant and non-dominant neuromuscular characteristics

	Mean	**SD**	**95% CI**			**df**	**Sig. (2-tailed**
			Lower	**Upper**	**t**		
Rectus femoris T_c	-.67	8.44	-2.51	1.17	-.72	82	.47
Rectus femoris T_s	9.03	60.28	-4.13	22.19	1.36	82	.17
Rectus femoris T_r	4.08	49.45	-6.70	14.88	.75	82	.45
Rectus femoris D_m	-.56	2.38	-1.08	-.043	-2.15	82	.034
Rectus femoris T_d	-.57	4.89	-1.63	.49	-1.06	82	.29
Vastus medialis T_c	.246	6.98	-1.27	1.7	.32	82	.74
Vastus medialis T_s	13.35	69.00	-1.71	28.41	1.76	82	.08
Vastus medialis T_r	10.42	64.77	-3.72	24.56	1.46	82	.14
Vastus medialis D_m	.21	1.61	-.13	.56	1.20	82	.23

Vastus medialis T_d	.14	2.80	-.47	.75	.46	82	.64
Vastus lateralis T_c	.55	8.92	-1.39	2.50	.56	82	.57
Vastus lateralis T_s	-.72	36.10	-8.60	7.16	-.18	82	.85
Vastus lateralis T_r	-5.82	54.96	-17.82	6.17	-.96	82	.33
Vastus lateralis T_d	-.81	2.12	-1.27	-.34	-3.47	82	.001
Vastus lateralis D_m	.61	5.99	-.69	1.92	.93	82	.35
Biceps femoris T_c	-2.27	11.67	-4.82	.27	-1.77	82	.08
Biceps femoris T_s	9.14	52.94	-2.41	20.70	1.57	82	.11
Biceps femoris T_r	5.41	41.64	-3.67	14.50	1.18	82	.24
Biceps femoris D_m	-.26	2.54	-.819	.290	-.94	82	.34

There was no significant difference in muscle symmetry between participants' on-field positions ($p = 0.05$, Table 4).

Table 4. ANOVA findings comparing muscle symmetry between different positions (goalkeeper, forwarder, midfielder and defender).

TMG data		df	SS	MS	F	p
Rectus femoris Sym	Between groups	3	337.67	112.55	0.92	0.44
	Within groups	79	9705.08	122.84		
	Total	82	10042.75			
Vastus medialis Sym	Between groups	3	188.49	62.82	0.70	0.56
	Within groups	79	7087.61	89.71		
	Total	82	7276.10			
Vastus lateralis Sym	Between groups	3	494.41	164.80	1.52	0.22
	Within groups	79	8583.81	108.65		
	Total	82	9078.22			
Biceps femoris Sym	Between groups	3	412.56	137.52	0.85	0.47
	Within groups	79	12777.51	161.74		
	Total	82	13190.07			

** df: degree of freedom, SS: sum of squares, MS: mean of squares, Sym: symmetry*

4. DISCUSSION

This study's main aim was to provide data regarding the neuromuscular profile of knee extensor and flexor muscles for a convenience sample of professional soccer players in the Saudi Premier League, and to determine if these values differed between on-field player positions.

The results highlighted low lateral symmetry in the knee extensor muscle BF, when adequate symmetry has been suggested to be above 80% (Di Salvo et al., 2007). Conversely, all flexor muscles demonstrated adequate symmetry. Various studies have linked muscular asymmetry with the prevalence of injuries and athletic performance (Bailey et al., 2013; Croisier et al., 2008; Wang & Fu, 2019). As well as being predictive of injuries, asymmetry can aid the clinical decision-making regarding return to play for athletes following injuries(Croisier et al., 2008; Wang & Fu, 2019; Wilk et al., 2003).

Compared to the neuromuscular profile of other data (8), there was minimal difference in knee extensor symmetry (2.5%). Nevertheless, the most considerable difference was observed in the VL (10.2%). It should be noted that all of the neuromuscular measurements of our sample were lower than reported in other studies (Di Salvo et al., 2007; García-García et al., 2017; Martín-Rodríguez et al., 2017; Rey et al., 2012; Yi et al., 2019).

A difference between right and left neuromuscular measures was observed only in RF Dm and VL Td. Conversely, parameters were not affected by foot dominance (Alvarez-Diaz et al., 2014). Like a Brazilian cohort (Alvarez-Diaz et al., 2014), the result suggests that player positions do not affect TMG values. However, our results contradict the data reported from Spanish elite football players, which suggest a significant influence of player position in FR Tc, Ts and Td (Rey et al., 2012). It should be noted that the latter study was conducted during the season, which may introduce some level of fatigue and influence the results (García-García et al., 2017).

Although football injury could be predicted by different factors (Di Salvo et al., 2007), there is inadequate evidence that preseason symmetry is associated with injuries incurred during the season (Rey et al., 2012). Alentorn-Geli et al.2014 reported that soccer players with anterior cruciate ligament injuries had higher Dm and Tc in the healthy limb than non-injured players. Thus, co-contraction of knee flexors and extensors could be linked to the balance between contractile mechanics, which might highlight a key predictor for injury risk (Wang & Fu, 2019).

This research area should be explored with caution as many factors could contribute to the neuromuscular system and its measurements, which therefore impact the causal relationship between inadequate symmetry and injury (Martín-Rodríguez et al., 2017).

The players' preseason performance needs to be documented and considered in many aspects, including the neuromuscular profile. To our knowledge, this is the first study with a relatively large sample size to establish the neuromuscular profile, using TMG, for premier league players before the beginning of the season.

The following limitations should be considered. First, a sample size calculation was not performed because we recruited a convenience sample of players who were willing to undergo testing. Therefore, our sample might not be representative, and type-II error must not be ignored. Secondly, we observed a high SD in some parameters in our sample, which may reflect the importance of standardizing testing and contextual factors that may influence the results.

This study provided normative data for the neuromuscular profile of knee extensor and flexor muscles measured with TMG, which the conditioning coach and physiotherapist may use to create preseason and competition recovery standards. Muscle contractile characteristics performance criteria may be used in professional soccer to monitor neuromuscular condition throughout the season, assess preseason and in-season athletes who may be at higher risk of muscle injury and might benefit from particular and tailored preventative programs, and track recovery from muscular injuries

The highest asymmetry was seen in the vastus medialis muscle and the lowest in the biceps femoris. The TMG values did not seem to be significantly affected by either dominance/non-dominance of the leg or the on-field player position. Therefore, when investigating TMG in athletes, extremity dominance isn't always a confounding factor to consider.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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