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ORIGINAL

FLEXIBILITY PROFILE OF LOWER-LIMB MUSCLE IN FUTSAL PLAYERS

PERFIL DE FLEXIBILIDAD DE LA EXTREMIDAD INFERIOR EN JUGADORES DE FÚTBOL SALA

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ABSTRACT

The purpose of this study was to quantitatively define the reference values of the flexibility profile of 20 professional futsal players. The flexibility of the major lower-limb muscles was assessed by means of 7 different maximum passive joint range of motion tests. The results of this study show that the assessed professional futsal players have higher flexibility profile values of lower-limb muscles than healthy sedentary adults and physically active adults. Likewise, the values of lower-limb flexibility of the professional futsal players tested are higher than those reported for professionals in other sports modalities.

KEY WORDS: Flexibility, range of motion, physical fitness, sports.

RESUMEN

El objetivo de este estudio fue definir cuantitativamente los valores de referencia del perfil de flexibilidad en 20 jugadores profesionales de fútbol sala. Para ello se valoró la flexibilidad de los principales grupos musculares de la extremidad inferior a través de 7 pruebas de rango de movimiento articular pasivo máximo. Los resultados obtenidos demuestran que los jugadores de fútbol sala analizados presentan un perfil de flexibilidad de la extremidad inferior superior a los valores propuestos para población general, a los valores encontrados en sujetos sanos sedentarios, así como en personas físicamente activas. De la misma forma, los valores de flexibilidad de los jugadores de fútbol sala seleccionados son superiores a los observados en otras modalidades deportivas.

PALABRAS CLAVE: Flexibilidad, rango de movimiento, condición física, deportes.

1. INTRODUCTION

Flexibility, defined as the ability to move a joint (or several joints in combination) through the whole range of motion (ROM) required for a specific activity or action (Magnusson and Renstrom, 2006), is one of the basic components of fitness for sports performance (Hahn, Foldspang, Vestergaard & Ingemann-Hansen, 1999; Alricsson & Werner, 2004). More specifically, Kraemer and Gómez (2001) claim that flexibility is one of the most essential elements of the maximum sport performance. This is especially noticeable in sports such as rhythmic and artistic gymnastics, diving and artistic skating, where flexibility is a key determinant of the performance. These sports require a maximum joint ROM (quantitative measure of muscle flexibility) in most joints in order to execute correctly the movements that are awarded the highest points by judges. Contrarily, sports such as football, basketball and athletics require lower values of flexibility to carry out the dynamic movements in the techniques involved (Nóbrega, Paula & Carvalho, 2005). Therefore, we could say that the importance of a high degree of flexibility varies according to the technical requirements of each sport modality (Canda Moreno, Heras Gómez & Gómez Martín, 2004).

Certain articles in the scientific literature assessing athletes´ flexibility show major differences in the results depending on the sport. Thus, we can observe that flexibility is specific for each joint, muscle action or movement (Hahn et al., 1999; Zakas, Galazoulas, Grammatikopoulou & Vergou, 2002) and that for the same sport the different joints require differing degrees of flexibility (Chandler, Kibler, Uhl, Wooten, Kiser & Stone, 1990; Probst, Fletcher & Seeling, 2007); flexibility also differs depending on the specific position of each player in a team (Oberg, Ekstrand, Möller & Gillquist, 1984), between the dominant and non-dominant sides (Magnusson, Gleim & Nicholas, 1984; Harvey, 1998; Chandler et al., 1990; Probst et al., 2007) and at each competitive level (elite vs. amateurs) (Gannon & Bird,1999; Haff, 2006; Battista, Pivarnik, Dummer, Sauer & Malina, 2007).

Along these lines, the study of Gannon and Bird (1999) shows that international athletes present higher flexibility values (shoulder flexion and extension ROM, hip flexion, extension and abduction ROM with full knee extension, trunk ROM and ankle ROM) than national, beginners or active athletes. Canda et al. (2004) on estimating hamstring muscle flexibility using the sit and reach test (SRT) in 32 different sports, concluded that elite athletes present higher flexibility values than the general population. Haff (2006) claims that Olympic swimmers present higher flexibility values than university swimmers. Battista et al. (2007) concluded that university rowers present better hamstring flexibility (SRT) than amateurs, and that experienced rowers have higher flexibility (0, 1, 2, 3 and 4 years).

Futsal is one of the most popular sports in Spain, with more than 100,000 federal licenses of all categories (RFEF (Spanish Football Federation, 2011). The National Futsal League is one of the most important leagues in the world regarding the number of international titles, and Spain is considered one of the world's leading powers in this sport (Álvarez, López, Echávarri, Quílez, Terreros & Manonelles, 2009). However, only one study has assessed the level of flexibility of futsal players using the SRT (Ayala, Sainz de Baranda, De Ste Croix & Santonja, 2011).

Establishing the flexibility profile of elite futsal players may be an useful tool for professionals of the Sports Sciences field, since it allows them to know the reference and normative values needed to achieve success in this sport. In addition, these reference values may be used as specific and quantifiable objectives of flexibility training as a basic physical quality to optimize physical and sports performance.

For this reason, the main aim of this study was to define quantitatively the flexibility profile reference values in 20 professional futsal players by assessing the flexibility of the main muscle groups of the lower limb through maximum passive joint range of motion exploratory tests.

2. METHOD

2.1. Participants

Twenty professional futsak players with over 8 years of experience (4-7 weekly training sessions of a minimum duration of 1.5 hours each), participated voluntarily in this study: 17 field players (age: 19.5±2.3 years; weight: 72,9±7,8 Kg; height: 174.7±5.4 cm) and 3 goalkeepers (age: 25.4±1.3 years; weight: 76.2±1.2 Kg; height: 164.5±2.2 cm). All players competed in the Spanish futsal silver league (second division) during the season 2010/11, and three of them also competed in the under-21 international league.

Both the athletes and their coaches were verbally informed about the methodology and the aims and possible risks of the study, and all of them gave written consent. The present study was approved by the Ethical and Scientific Committee of the University of Murcia (Spain).

2.2. Procedure

One week before the study commenced, all participants filled in a sports medicine questionnaire (personal details, anthropometric data, sports data, history of injuries, experience with stretching exercises and any history of stressed muscle groups during competition), and they underwent a session to familiarise themselves with the correct technical execution of the exploratory tests, practising each of them in turn. A second aim of this session was to reduce the possible learning bias on the results obtained in the different assessment tests (Ayala & Sainz de Baranda, 2011). In addition, in order to ascertain the players' dominant limb, during this session all the subjects were required to pass three tests: 1) jumping on one leg; 2) kicking the ball; and 3) climbing onto a stool with one leg according to the methodology of Wang, Whitney, Burdett and Janosky (1993). The limb used to do at least 2 of the 3 tests was considered the dominant one.

In order to assess the passive ROM of the lower limb main muscle groups, we followed the recommendations established by the American Academic Orthopedic Association (1965) and Sady, Wortman and Blanke (1982). As recommended, the assessment session was always carried out by two experienced clinicians, one of whom ensured the subject's correct position during the whole assessment process (stabilization of body segments), while the other conducted the test, and all tests took place in the same weather conditions and at the same time of day. These measures were taken in order to minimize the possible influence that inter-examiner variability and circadian rhythms may have on the results (Atkinsom & Nevil, 1998). Both clinicians were blinded of the study's aims. In addition, the subjects were asked to do the test on a day and at a time that coincided with their usual training sessions in order to minimize intra-subject variability (Hopkins, 2000).

During the assessment session, and before the application of different exploratory tests of the maximum passive joint ROM, all participants performed 10 minutes of aerobic warm-up (low intensity jogging [10-12 on the Borg scale]) together with a series of standardised static stretching exercises (Gabbe, Bennell, Wajswelner & Finch, 2004), working on the lower limb muscles, under the strict supervision of the examiners. The aerobic warm-up intensity and duration was determined according to the recommendations of Bishop (2003), who studied in depth the bibliography of the warm-up and concluded that in order to maximise the increase of muscle temperature and optimise subsequent performance it is necessary to carry out actions of global mobility (running mainly) for approximately 10 minutes at intensities of 40-60% VO_2max.

The stretching exercises (n=7) selected were intended to imitate each of the positions adopted in the selected assessment tests (figure 1). Previous studies have suggested that modifications caused by stretching exercises on the viscoelastic properties of muscle remain stable for at least 20 minutes after the application of stretching exercises of 90 to 180 seconds (Ford & McChesney, 2007; Magnusson, Aagard, Simonsen & Bojsen-Moller, 1998; Power, Behm, Cahill, Carroll & Young, 2004). For this reason, in order to ensure stability in muscle properties during the assessment process, the stretching sequence presented a total volume of 90 seconds per muscle group (3 series of 30 seconds per exercise and leg).

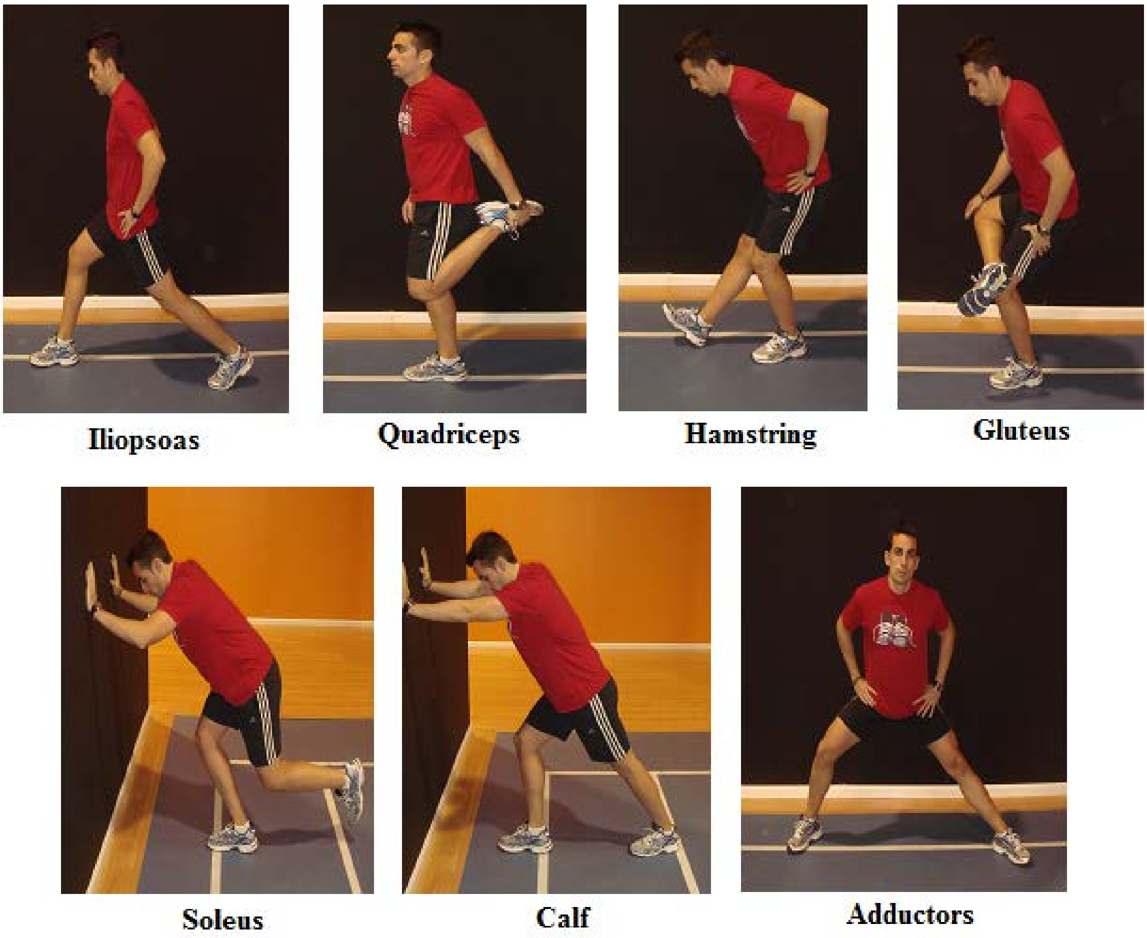

Figure 1: Static stretching exercises (3x30s/exercise and leg)

The aerobic warm-up and standardized sequence of static stretching exercises were carried out for the following reasons: 1) all assessment tests subject the lower limb muscles to maximum tension; and 2) they are intended to minimise the standard variability and error of the measure by reducing the effect that the stretching and the different muscle temperature have on the viscoelastic properties of the soft tissue (Dixon & Keating, 2000).

Once the warm-up and stretching exercises were over, we assessed flexibility by measuring the maximum passive ROM of a joint (Alter, 2004; Bradley, Olsen & Portas, 2007) with each of the joint ROM tests (figure 2). The subjects were asked to make two maximum efforts for each of the assessment tests and body segments (dominant and non-dominant), carrying them out in a random order so as to avoid the possible bias that a specific sequence may present on the results obtained. This random order of the assessment tests was determined by computer http://www.randomizer.org.

For the flexibility assessment session we used an adjustable stretcher and, as a measuring tool, an ISOMED Unilevel inclinometer with telescopic arm, according to the recommendations of Gerhardt (1994) and Gerhardt, Cocchiarella and Lea (2002).

Participants wore sportswear and were barefoot. They were allowed to rest for 2 minutes between tests (Ayala & Sainz de Baranda, 2011) and for approximately 30 seconds between the two maximum efforts made for each test.

The final result of each maximum attempt for each assessment test was determined by one or more of the following criteria: 1) the evaluator was unable to do the evaluated joint movement in a slowly and gradually (without jerking) due to the high resistance developed by one or more stretched muscle groups during the exploratory process (American Academic of Orthopedic Association, 1965); 2) the participant complained of discomfort due to the stretching of a muscle (Ekstrand et al., 1982; Zakas, Vergou, Grammatikopoulou, Sentelidis & Vamvakoudis. 2003; Nelson & Bandy, 2004); or 3) both evaluators appreciated a compensatory movement that increased the joint ROM (Ekstrand et al., 1982; Clark, Christiasen, Hellman, Winga & Meiner, 1999; Sainz de Baranda & Ayala, 2010).

The average value of the two attempts at each assessment test was taken into account for the subsequent statistic analysis (Ayala & Sainz de Baranda, 2011; Khan et al., 2000; Gabbe et al., 2004). The two maximum attempts at each test and the use of the average value were based on the intra-session reliability results previously obtained by the evaluators for each of the exploratory procedures. One month before the assessment session, a double-blind study had been carried out with 20 physically active individuals (different to the participants in this study) using the traditional test-retest design. The ROM was measured twice with an interval of 20 minutes, with no significant differences (systematic bias). The intra-session reliability of each variable was determined by the intraclass correlation coefficient ($ICC_{2,1}$) using the method previously described by Hopkins (Hopkins, 2000; Hopkins, 2009). The ICC was over 0.90 in all exploratory tests, which shows high stability of the measure.

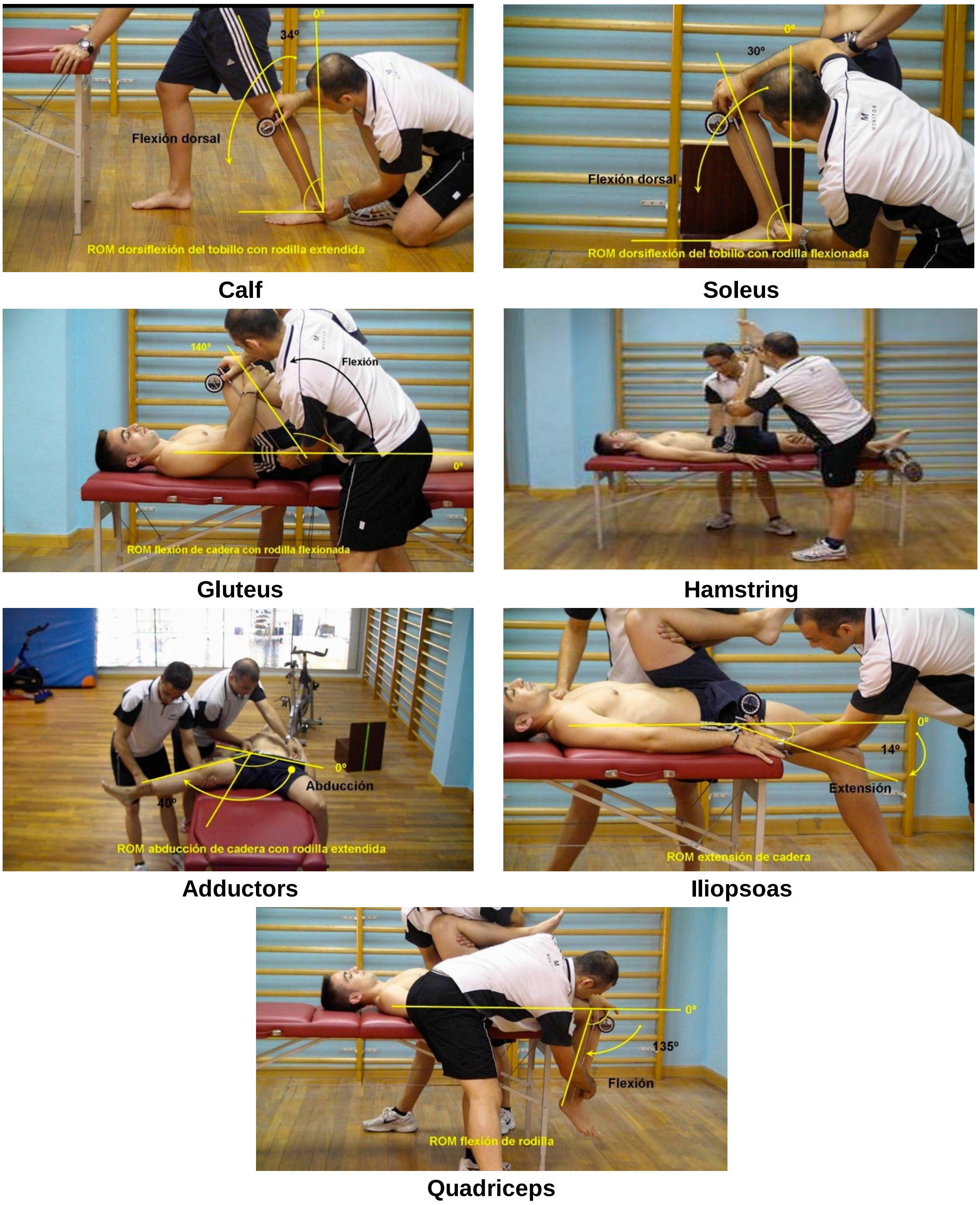

Figure 2: Graphic representation of the 7 assessment tests of the maximum passive joint ROM used in this study

2.3. Statistical analysis

Prior to the statistical analysis, the normal distribution of the data was confirmed using the Kolmogorov-Smirnov test. A descriptive analysis of each quantitative variable was carried out, including the mean and its corresponding standard deviation. In addition, a t-test for related samples was used to check for differences between the dominant and non-dominant lower limb values. Furthermore, a t-test was applied for independent samples in order to check for possible differences between field players and goalkeepers.

The statistical analysis was performed using the Statistical Package for Social Sciences (v. 16.0, para Windows; SPSS Inc, Chicago) with a significance level of 95% ($p<0.05$).

3. RESULTS

Table 1 presents the results of the 7 assessment tests with separate columns for dominant and non-dominant data.

Table 1: Values of the máximum passive joint ROM of professional five-a-side field players (n=17) and goalkeepers (n=3).

	Field players		Goalkeepers	
	Dominant	**Non-dominant**	**Dominant**	**Non-dominant**
DFKE-calf	40.1º±5.1º	39.9º±4.6º	49.1º±2.3º*	47.6º±4.2º*
DFKF-soleus	39.7º±4.2º	39.8º±4.3º	50.8º±0.7º*	47.8º±1.6º*
HF-gluteus	143.5º±4.5º	143.3º±5.1º	142.1º±1.1º	142.8º±2.2º
SLR-hamstring	91.7º±9.2º	90.5º±9.1º	102.9º±3.7º	103.5º±3.4º
ADD-adductors	51.6º±7.1º	51.8º±5.9º	58.3º±0.4º	56.3º±2.3º
HE-iliopsoas	12.4º±3.3º	12.5º±3.4º	17.4º±1.4º	17.6º±1.4º
KF-quadriceps	139.5º±6.6º	138.6º±6.5º	145.3º±3.3º	147.6º±4.4º

DFKE-calf: ankle dorsiflexion with full knee extension ROM; DFKF-soleus: ankle dorsiflexion with knee flexion ROM; HF-gluteus: hip flexion with knee flexion ROM; SLR-hamstring: hip flexion with knee extension ROM or straight leg raise test; ADD-adductors: hip adduction with knee extension ROM; HE-ilipsoas: hip extension ROM; KF-quadriceps: knee flexion ROM; *: significant differences between field players and goalkeepers ($p<0.05$).

When analysing the data on the dominant and non-dominant leg, no significant differences were found ($p<0.05$) for either field players or goal keepers (table 1), and so the flexibility profile was determined using the mean of both limbs. The t-student test for separate samples did not show significant differences between field players and goal-keepers ($p>0.05$) regarding the different joint ROM studies, with the exception of ankle dorsiflexion with full knee extension (calf) and the ankle dorsiflexion with knee flexion (soleus).

4. DISCUSSION

The main aim of this study was to assess the ROM of the main joint movements of the lower limb in 29 professional futsal players. These data are important in order to define quantitatively the reference or normative flexibility profile in this sport, since the physical and technical demands may require certain musculoskeletal adaptations (Chandler et al., 1990; Hahn et al., 1999; Irurtia, Busquets, Carrasco, Ferrer & Marina, 2010), and, as a result, a specific flexibility profile determined according to the type of sport and the specialisation of each specific playing position (Gleim & McHugh, 1997).

In the scientific literature there are no studies which assess the joint ROM (using angular movement tests) in futsal players, so we can only compare the results of this study with those obtained for other athletes or for non-active people. As table 2 shows, the flexibility values of the participants in this study are higher than the proposed values for the population as a whole (Alter, 2004, American Academy of Orthopedic Surgeons, 1965; Gerhardt, 1994; Norkin & White, 2006; Clarkson, 2003; Gerhardt, Cocchiarella & Lea, 2002; Palmer & Epler, 2002), than the values obtained for healthy sedentary people (Clapis, Davis & Davis, 2008) and than those of physically active people (Probst et al., 2007).

Likewise, the flexibility values obtained for futsal players analysed in the present study are higher than those obtained for players of other sports (tennis, basketball, long-distance runners) (table 3). However, we must bear in mind the fact that most studies on flexibility in other sports measure only one or two joint ROMs (Worrell, McCullough & Pfeiffer, 1994; Young, Clothier, Otago, Bruce & Liddell, 2003; Bradley, Olsen & Portas, 2007; Rahnama, Lees & Bambaecichi, 2005; Probst et al., 2007; Johanson, Baer, Hovermale & Phouthavong, 2008; Clapis et al., 2008).

These results are somewhat surprising, since elite athletes in sports involving jumps, sprints, changes of direction and sense, with a high intensity of the stretch-shortening cycle (SSC), such as futsal, usually present a tendency to muscle shortening (Chandler et al., 1990; Worrell & Perrin, 1992). The professional level of the sample and the correct planning of their flexibility training sessions, together with other performance parameters, may explain these results.

Table 2. Joint ROM reference values in goniometry and in non-professional adult sportsmen.

	DFKE Calf	DFKF Soleus	HP Gluteus	SLR Hamstring	ADD Adductors	HE Ilipsoas	KF Quadriceps
Five-a-side football Present study	**40º**	**40º**	**143º**	**91º**	**52º**	**13º**	**139º**
Goniometry[1]	0º-10º	0º-30º	115º-140º	80º	0º-45º† 0º-50º‡	0º-30º	0º-150º
Non-professional adult sportsmen							
Worrell et al. (1994)	35.13º						
Johanson et al. (2008)	31.8º						
Ekstrand et al. (1982)	22.5º	24.9º		81º	37º	83.5º	
Peeler et al. (2008)							47.2º
Clapis et al. (2008)						-1.7º† -2.8º‡	
Mahieu et al. (2007)	28.4º	36.7º					
Probst et al. (2007)						20.4º	

DFKE: ankle dorsiflexion with full knee extension ROM; DFKF: ankle dorsiflexion with knee flexion ROM; HF: hip flexion with knee flexion ROM; SLR: hip flexion with knee extension ROM or straight leg raise test; ADD: hip adduction with knee extension ROM; HE: hip extension ROM; KF: knee flexion ROM; [1]: normative values established by the American Academy of Orthopedic Surgeons (1965) and used in a great number of studies (Gerhardt, 1994; Norkin & White, 2006; Clarkson, 2003; Gerhardt et al., 2002; Palmer & Epler, 2002; Alter, 2004); †: men; ‡: women.

On the other hand, the scientific literature reports that the degree of flexibility is specific depending on the position each player occupies in the same sport (Oberg et al., 1984), and goalkeepers tend to present higher values than field players (Oberg et al., 1984). The results obtained in the present study agree with this finding, since they show a significant difference ($p<0.05$) in joint ROM assessment tests for the calf and the soleus.

Furthermore, as a part of the flexibility profile analysis, the scientific literature proposes assessing the differences between the dominant and the non-dominant leg (Magnusson et al., 1984; Harvey, 1998; Chandler et al., 1990; Probst et al., 2007), since certain skills and specific physical demands may cause different musculoskeletal adaptations for the limb, depending on whether it is the more or less skilled of the two.

Table 3: Joint ROM values in different sports players.

	DFKE Calf	DFKF Soleus	HF Gluteus	SLR Hamstring	ADD Addctors	HE Ilipsoas	KF quadriceps
Five-a-side footbal Present study	**40º**	**40º**	**143º**	**91º**	**52º**	**13º**	**139º**
Professional football (Witvrouw et al, 2003)	35.7º			94.6º	53.3º		
Sub-elite male football (Rahnama et al., 2005)				90.7º			
Teen male football (Zakas, 2005)		37.4º		82.7º	44.8º	14.3º	
Teen male football (Zakas et al., 2006)		26.1º		79.3º	39.8º	6.8º	
Elite football (Bradley et al., 2007)			102.1º				
Male football (Ekstrand et al., 1982)	21.4º		102º	80.8º	33.5º	9.1º	
Junior handball (Zakas et al., 2002)		29.8º		76.3º	46.5º	8.2º	
Junior handball (Zakas et al., 2003)		29.2º		79.8º	45.3º	8.2º	
Adolescent elite tennis (Zakas, 2005)		27.7º		68.5º	41.5º	24.8º	
Male elite junior tennis (Chandler et al., 1990)				77.5º			124º
Male elite junior tennis (Kibler et al., 2003)				65.9º			123.1º
Cross-country skiers (Alricsson y Werner, 2004)	35.5º			99º			
Runners a) 30-55 millas/semana b) 76 millas/semana (Wang et al., 1993)	a) 9.1º b) 6.6º	a) 19.1º b) 16.3º		a) 76.7º b) 65.5º			
Male Australian Football (Young et al., 2003)						13.7º	
Tang Soo Do Karate (Probst et al., 2007)						22.4º	

DFKE: ankle dorsiflexion with full knee extension ROM; DFKF: ankle dorsiflexion with knee flexion ROM; HF: hip flexion with knee flexion ROM; SLR: hip flexion with knee extension ROM or straight leg raise test; ADD: hip adduction with knee extension ROM; HE: hip extension ROM; KF: knee flexion ROM.

Bilateral imbalances between the flexibility level in dominant and non-dominant limb have been related with an increment of injury risk (Bozic, Pazin, Berjan, Planic & Cuk, 2010; Probst et al., 2007). Therefore, in this study we defined the flexibility profile for the dominant and non-dominant limb depending on the specific position. The statistical analysis did not show significant differences between the dominant and the non-dominant leg in any of the joint ROMs, so, taking into account this risk factor, players of this team present a lower injury risk.

5. CONCLUSIONS

The results obtained in this study show that the futsal players analysed present a higher flexibility profile in the lower limb than the general population, healthy sedentary people and physically active people. Furthermore, the flexibility values of the selected futsal players are higher than those obtained by athletes of other sports (football, tennis, handball, long-distance runners). Finally, there are no bilateral muscle imbalances between the dominant and non-dominant leg flexibility level in any of the joint motions studied.

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