


Does the type of sport practised influence foot posture and knee angle? Differences between footballers and swimmers

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ABSTRACT

This aim of this study is to observe the differences in foot posture and the angle of the knee according to different physical activities. Seventy-eight football players and 72 swimmers were recruited, and in each case a foot posture analysis, based on the foot posture index (FPI), was conducted and the Q angle of the knee was determined. The following mean values were obtained for the lower extremities: in the swimmers, FPI 6.45 ± 2.04 and Q angle $15.38^\circ \pm 3.79^\circ$. In the footballers, FPI 2.23 ± 1.72 and Q angle $13.16^\circ \pm 1.36^\circ$. There were statistically significant differences ($p < 0.001$) between the two groups. The swimmers presented a foot posture with a tendency towards pronation, and a Q angle with a tendency towards valgus, while the results for the footballers were within the normal range.

KEYWORDS

Foot; knee; swimming; football; foot posture; Q angle

Introduction

The popular endurance sports of swimming, road cycling and mountain biking all produce high-repetition, low-magnitude muscle forces with unidirectional movements in appendicular limbs, which persist in a continuous fashion, in contrast to more explosive sports, such as football, which require the development of more powerful muscles to exert the forces necessary to perform specific technical gestures. Sports such as swimming are thought to provide little additional osteogenic stimuli over and above those derived mainly from the torsional strain exerted on bones due to muscle contractions (Rantalainen, Nikander, Heinonen, Suominen, & Sievänen, 2010; Rector, Rogers, Ruebel, & Hinton, 2008). On the other hand, greater osteogenic stimulus is produced in sports where the body mass is unsupported (i.e. weight-bearing sports), those requiring irregular directional movements, and/or jumping or landing from heights (i.e. impact sports) and those involving movement against external loads (Nikander et al., 2010; Rantalainen, Nikander, Daly, Heinonen, & Sievänen, 2011; Rantalainen et al., 2010). The above-mentioned endurance sports include only some or none of these attributes: thus, while football is both weight-bearing and includes high impact-loading (Groothausen, Siemer, Kemper, Twisk, & Welten, 1997; Hong, 2016), swimming and road cycling are both non-weight-bearing and non-impact-loading.

Sports training programmes vary and, according to the sport in question, may be conducted with or without load, and with or without footwear. Mechanical load and other biomechanical parameters can be manipulated by the use of interval training (Azevedo et al., 2015; Brughelli, Cronin, & Chaouachi, 2011; Hamill, Bates, Knutzen, & Sawhill, 1983; Støren, Helgerud, & Hoff, 2011). Although few guidelines have been proposed in this respect, expected benefits include performance enhancement and injury prevention (Wanivenhaus, Fox, Chaudhury, & Rodeo, 2012).

Foot posture and knee alignment may influence sports biomechanics. The pronated foot or knee provokes alterations in the gait cycle, and can produce sports injuries (Hahn & Foldspang, 1997). In this respect, different sports are associated with different outcomes (Martinez-Nova et al., 2014), which may also be influenced by the history of sports practice, especially when dedicated to a single discipline (Uzel, Cetinus, Ekerbicer, & Karaoguz, 2006).

This aim of this study is to identify the different effects exerted by football and swimming with respect to foot posture and the angle of the knee.

Method

Study design

A cross-sectional study was performed.

Participants

This study was conducted with 150 participants, presenting the characteristics shown in Table 1. The study population was composed of 78 football players and 72 swimmers, all aged 15–21 years. All participants were recruited between December 2015 and June 2016 at federated sports clubs in the provinces of Malaga and Granada (Spain), according to the following inclusion criteria: male, aged over 15 years, having regularly practised competitive football or swimming during the last six years (a period considered sufficient for the influence of the sport to become apparent) (Uzel et al., 2006), not having practised any other sport in this period, and training at least 10 hours per week. Exclusion criteria were the presence of an injury in the lower limb that modified the posture at the time of measurement or during the last six months, having suffered a fracture in the lower limb, or having had surgery affecting the lower limb, balance problems, congenital malformation of the lower limbs, refusal to participate in the study or failure of the legal guardians to provide signed consent.

Table 1. Characteristics of the sample: footballers vs. Swimmers.

	Footballers				Swimmers			
	Mean	SD	95% CI		Mean	SD	95% CI	
Age	17.30	1.04	16.79	17.26	17.21	1.72	16.80	17.61
Practice (yrs)	9.44	1.67	9.06	9.81	8.76	2.11	8.27	9.26
Training h/wk)	12.32	0.78	12.14	12.50	19.39	4.00	18.45	20.33
Shoe size(European size)	42.21	1.88	41.78	42.63	42.78	2.14	42.27	43.28
Weight(Kg)	65.63	5.67	64.35	66.91	63.83	5.83	62.46	65.20
Height(Meter)	1.74	0.05	1.73	1.75	1.75	0.06	1.73	1.76
BMI(Kg/m ²)	21.63	1.39	21.31	21.94	20.93	1.19	20.65	21.21

Informed verbal and written consent was obtained from all participants before enrolment, and all of the rights of the participants were protected. This study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the University of Malaga (Spain).

Procedure

All subjects were interviewed to obtain demographic data and for clinical examinations to be conducted. The demographic data included age, number of years practising the sport, number of training sessions per week and type of sport. The measurement protocol was conducted by two podiatrists, who had been specifically trained for this task. The study was conducted with the subjects wearing appropriate clothing (shorts), so that the anatomical points could be easily located and viewed.

The FPI was assessed in both feet by a podiatrist (GGN) with a high previously-established intra-rater reliability for FPI scoring (intra-class correlation coefficient (ICC = 0.91–0.98), who was blinded to the purposes of the study and to the participant's identity. The FPI is a six-item clinical assessment tool used to evaluate foot posture (Redmond, Crosbie, & Ouvrier, 2006). It has acceptable validity (Keenan, Redmond, Horton, Conaghan, & Tennant, 2007) and good intra-rater reliability (Cornwall, McPoil, Lebec, Vicenzino, & Wilson, 2008). The FPI evaluates the multi-segmental nature of foot posture in all three planes, and does not require the use of specialised equipment. Each item of the FPI is scored between –2 and +2, to give a total between –12 (highly supinated) and +12 (highly pronated). Items addressed include talar head palpation, curves above and below the lateral malleoli, calcaneal angle, talonavicular bulge, medial longitudinal arch and forefoot to hindfoot alignment.

The Q-angle is defined as the angle between a line connecting the centre of the patella and the patellar tendon attachment site on the tibial tubercle and a second line connecting the centre of the patella and the anterior superior iliac spine on the pelvis when the knee is fully extended. The Q-angle normally varies between 13° and 18°, with a mean value of approximately 15°, and angles outside this range are considered abnormal (Hahn & Foldspang, 1997). Femoral-tibial angles were measured in both knees using a tripod-mounted Sony A380 camera to take a photograph of the front and rear of the subject's leg. Then, the Q angle under load was determined by computer software, following the method described by Sánchez-Machado et al. (Sanchez, De Sanchez, Baraúna, & De Canto, 2014) to assess knee alignment with respect to the hip and tibia. To do so, the subject was asked to stand evenly on both feet at a height of 0.90 m above the ground, and the camera was placed at a distance of 2.90 m, to obtain a complete picture of the entire lower limb. To standardise the image, the heels were separated by 7.5 cm and the forefoot was rotated by 10°. The precision of these measures was ensured by previously marking the surface on which the subject was to stand. The subject was asked to stand with his muscles relaxed, arms hanging vertically beside the trunk, head straight and looking at a given point on the wall. The Q angle was obtained by reference to the anterior superior iliac spine, the centre of the patella and the anterior tibial tuberosity, with the centre of the patella forming the apex of the angle between the femur and the tibia, such that these points would be clearly visible in the photograph. In this process, the software used, CorelCAD 2014®, was specially designed for the accurate measurement of angles in photography (ABOA).

Statistical analysis

The number of participants in the study population was determined using EPIDAT 4.1 software (Xunta De Galicia, 2010), taking as the main variable the FPI according to Martínez-Nova et al. (Martínez-Nova et al., 2014). The study was designed to detect changes with an effect size greater than 0.8 (high effect size), to calibrate mean changes, with a type I error of 0.05 and a type II error of 0.2. This test showed that a study population of 65 subjects per group would be required. Assuming a dropout rate of 10% during the study, the final sample size needed, thus, was 72 participants per group.

The data obtained were analysed with IBM SPSS19® (SPSS Science, Chicago, IL) statistical software. Descriptive statistics of the variables were used to observe the means and standard deviations of the quantitative variables for each study group. The hypothesis of normality in the population distribution was confirmed by the Lilliefors-corrected Kolmogorov-Smirnov test. The paired-samples t test was used to compare the mean Q angle and FPI measures obtained for the different positions. The mean Q angles and FPI values obtained for each group were compared by using an independent samples t test. In all these tests, the criterion for statistical significance was $p < 0.05$.

Results

Among the footballers, the mean Q angle was 13.10 degrees (SD1.34) in the right leg and 13.23 (SD 1.38) in the left leg, while among the swimmers the corresponding values were 15.57 (SD 3.96) in the right leg and 15.19 (SD 3.63) in the left (Figure 1). With respect to foot posture, the FPI produced average values of 2.27 (SD 1.77) for the right

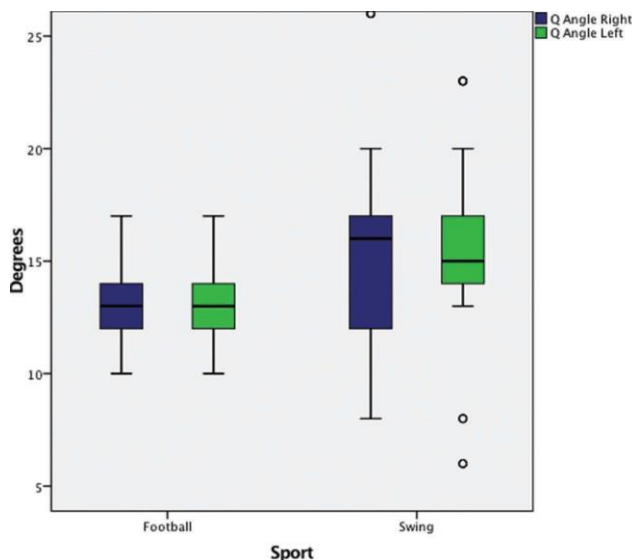


Figure 1. Box and whisker plot of changes in the Q angle of swimmers and footballers. The box represents median, lower, and upper quartiles and the lower and upper inner fence. Points represent extreme values over the upper inner fence or under the lower one.

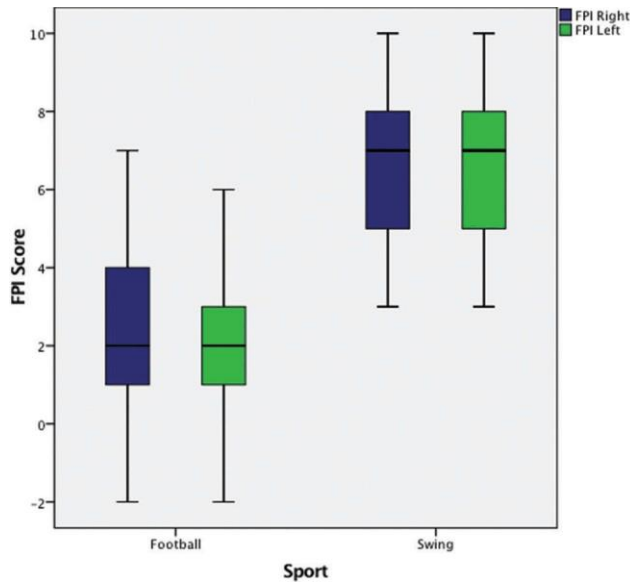


Figure 2. Box and whisker plot of changes in the FPI of swimmers and footballers. The box represents median, lower, and upper quartiles and the lower and upper inner fence. Points represent extreme values over the upper inner fence or under the lower one.

Table 2. Outcome data for FPI and Q angle (lower limbs, right and left).

	Difference of the means	Difference of the standard error	95% CI		P-value
Q angle (R)	-2.467	0.475	-3.406	-1.528	<0.001
Q angle (L)	-1.964	0.441	-2.836	-1.092	<0.001
FPI(R)	-4.272	0.318	-4.901	-3.644	<0.001
FPI(L)	-4.169	0.298	-4.758	-3.58	<0.001

foot and 2.19 (SD 1.68) for the left (footballers) and 6.54 (SD 2.12) for the right foot and 6.36 (SD 1.97) for the left (swimmers) (Figure 2).

Analysis of these measures revealed statistically significant differences ($p < 0.001$) between the two groups of athletes, both in the right and in the left limb (Table 2).

Discussion

The aim of this study was to determine whether there were differences in foot posture and knee angle between athletes practising two different sports: football, in which weight bearing is significant, and swimming, in which the lower limb is unaffected by gravity and needs only overcome the resistance of the water.

Among the swimmers, the foot posture presented pronation, according to the FPI criteria defined by Redmond (Redmond, Crane, & Menz, 2008), scoring 4.42 points (right foot) and 4.17 points (left foot) more than the footballers, whose foot posture was within the range of normality. Among the swimmers, the Q angle of the knee was within the range of genu valgus, with angles greater than 15° in both limbs, while among the footballers the Q angle was within the normal range, with values close to 13° (Sanchez et al., 2014).

The FPI values obtained indicate that the swimmers had a more strongly pronated foot posture. This finding is accounted for by the biomechanical technique applied to the lower limb by swimmers, together with the effect of the type of training – mainly in the water – in this sport (Krabak, Hancock, & Drake, 2013). In the aquatic environment, less resistance is offered and body weight is decreased, and therefore the muscle activity of the lower limbs is reduced (Liebenberg et al., 2011). The technical gestures affecting the foot, independently of the style employed, consist mainly of internal rotation, plantar flexion of the ankle and inversion, while the knee remains in slight flexion. This pattern of movements provokes a muscular weakness in the ankle and facilitates pronation of the foot (Aspenes & Karlsen, 2012). The sample of footballers presented mean FPI values of 2.27 and 2.19 in the left and right foot, respectively, with a tendency towards the neutral position. These values contrast with those reported by Cain et al. (Cain, Nicholson, Adams, & Burns, 2007) for players of indoor football (FPI = 5.3 ± 2.9) and by Burns, Keenan, and Redmond (2005) (Burns et al., 2005) for triathletes (FPI = 5.1 ± 3.9) (with a tendency towards the pronated position). This discrepancy may have arisen due to differences in the technical gestures employed and in the surface on which the sport is practised. However, both for these triathletes and for our sample of swimmers, the data obtained indicate a pronated position. For triathletes, perhaps the multifaceted nature of this sport (running, swimming and cycling) promotes balanced muscular activity and helps maintain an appropriate position of the foot.

With respect to the mean Q angle recorded in our study, for footballers and swimmers, significant differences were observed among the participants, with a tendency towards genu valgus among the swimmers, but not among the footballers. This finding corroborates Heiderscheit et al. (Heiderscheit, Hamill, & Caldwell, 2000), who concluded that altered segment and joint kinematics, as a result of an excessive Q angle, can provoke an increased genu valgus angle, increasing rearfoot eversion and modifying tibial internal rotation angles (Sendur, Gurer, Yildirim, Ozturk, & Aydeniz, 2006). In our study, this would explain the fact that the swimmers presented a tendency towards a pronated foot posture, due to the physical actions required by the sport and the environment in which it takes place. However, there was no agreement between our findings and those of Hahn et al. 1997 (Hahn & Foldspang, 1997), for whom the Q angle was negatively associated with years of football practice and swimming, although the highest values for the Q angle were found to be associated with the lower right limb.

The main limitation of the present study is the gender of the sample group, since only male athletes were taken into account. Thus, the study population was composed of a convenience sample, which may have introduced some bias into the results obtained. Another limitation may be the influence of age, as the subjects in our study were adolescents or young adults, and this fact may influence the position of the foot (although comparable variations have been observed among adult athletes (Gijon-Nogueron et al., 2015)). For future research, the sample population should be expanded to include female subjects, as the Q angle is generally considered to be greater among women than men. Another area of interest would be to extend the scope of the research to other sports in which there is a combination of aquatic and non-aquatic environments, and to evaluate other factors that may influence the Q angle, such as the position of the patella.

The data obtained in this study lead us to suggest that the environment in which a sport or type of training takes place directly influences the muscular activity of the lower

limb, and therefore the Q angle that adapts the position of the foot to the terrain and helps avoid injuries.

The results presented could be of interest both to clinicians and to researchers interested in the prevention of lower limb injuries in different sports. Prevention strategies such as foot orthosis-taping, as well as therapeutic exercise based on strengthening weak muscles involved in specific foot postures, should be considered.

Conclusions

In our study population, the swimmers presented a foot position with a tendency towards pronation, according to the FPI values obtained, and a Q angle with a tendency towards valgus, while the results for the footballers were within the normal range both for foot posture and for knee angle.

Conflict of interest

All the authors declare that they have no conflict of interest derived from the outcomes of this study.

Disclosure statement

No potential conflict of interest was reported by the authors.

Ethical approval Institutional Review Board that approved the protocol for the study

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