

Clinical Characteristics in U19 Elite Soccer Players, Implications on Injury Prevention

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Abstract: Background: Young soccer players' injuries are receiving increased interest. The need of adopting injury prevention strategies to reduce financial, social and sport costs is obligated. The main purpose of this study is to analyse clinical characteristics of young soccer players in order to develop specific and effective injury prevention programs. Methods: This observational, transversal study includes 25 young soccer players from Spanish National League. Strength, motor control, flexibility and range of motion characteristics were analysed before the first preseason training. Results: Statistically significant differences were found for hip internal rotation (p value = 0.001), Thomas test (p value = 0.012) and ankle dorsiflexion test (p value = 0.009) between both sides. Dorsiflexion test showed a positive correlation with the hip internal rotation ROM ($p < 0.016$) and with the triple hop test ($p < 0.007$). The hip internal rotation ROM showed a positive correlation with the Thomas test ($p < 0.033$) and with the single leg squat test ($p < 0.008$). The drop jump test showed a positive correlation with the single leg squat test ($p < 0.039$). Conclusions: Clinical characteristics shown in this study should be taken into account in order to develop specific injury prevention for this specific population. Moreover, data shown in this study can be used as norm values for young soccer semi-professional players in future researches.

Key words: Youth sports, soccer, prevention and control.

1. Introduction

Soccer is one of the most popular sports worldwide and injuries are the most common reason for unavailability to practice it [1]. Many authors have studied the injury incidence in professional adult soccer players, showing a range of 8.7 to 65.9 injuries per 1,000 h of match exposure [2]. Pfirrmann D et al. found a range of 9.5 to 48.7 per 1,000 h of match exposure in elite young players aged 16-19 [2]. These data suggest that injuries in elite young players are a problem as important as injuries in adult professional

footballers or more.

Soccer injuries, aged regardless, have a high social, financial and performance impact. There is a significant association between the number of injuries suffered by the team players and his classification position, showing that injuries affect negatively the team performance [3]. Moreover, injuries have a psychological effect on the player and this could affect his own performance along his sport career [4].

The need of adopting injury prevention strategies to reduce financial, social and sport costs is obligated as shown before. Injury strategies are usually aimed to improve neuromuscular characteristics. Warm up routines have also been described to impact injury prevention and performance in both team and

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individual sports [5, 6]. Decreased strength [7], motor control [8, 9], flexibility [10] or range of motion [11] have been shown as possible risk factors to suffer a sport injury. The analysis of these neuromuscular parameters is crucial to develop a specific prevention approach, as lot of professional clubs are doing at this moment [12].

The aim of this study is to analyse the clinical characteristics of a semi-professional youth football team in order to detect some neuromuscular deficits that could help to: (1) understand specifically some injuries incidence and (2) to plan appropriated injury prevention strategies.

2. Methods

2.1 Experimental Approach to the Problem

This study is an observational study aimed to investigate the clinical characteristics of young soccer players. Clinical characteristics such as motor control, strength, flexibility and range of motion were analysed. A second aim of the study was to discuss about the impact of this clinical characteristics founded with norm values and risk factors shown in other studies. Moreover, such information could be used as young soccer player's reference values.

2.2 Subjects

Thirty (30) semi-professional young soccer players aged 17 to 19 from a national Spanish league team participated in this study. The inclusion criteria for the study were (i) not to have been injured during last 3 months and (ii) to have signed (parents in case of subjects under 18) the informed-consent. Five subjects did not meet the first item so finally, 25 subjects completed the study.

This study was approved by the local Ethics Committee and it satisfies the World Medical Association Declaration of Helsinki. Subjects were informed of the benefits and risks of the study prior to signing the informed-consent. Moreover, parents of subjects aged under 18 were equally informed of the

study and they also signed the informed-consent.

Subjects mean (\pm SD) height, weight and BMI was 1.78 (\pm 0.07) cm (range 1.61-1.92), 68.81 (\pm 5.76) kg (range 59.3-81.8) and 21.73 kg/m² (\pm 1.33) (range 19.66-24.02). There were 3 goalkeepers (12%), 9 defenders (36%), 5 midfielders (20%), 4 wings (16%) and 4 strikers (16%).

2.3 Procedures

Data collection was carried out during 2018/2019 preseason, before the first training session. Clinical characteristics as strength, motor control, flexibility and range of motion (ROM) were analysed. Each variable was analysed through scientifically validated screening tests. Tests used to each variable are described below.

2.3.1 Strength

(1) Triple Hop for Distance

This test aims to evaluate the lower limb strength and has been scientifically validated for this purpose. Subject has to perform three consecutive maximal hops forward on the same limb and total distance with each limb being measured with a single meter, as Meierbachtol et al. did [13].

(2) Countermovement Jump

This test aims to evaluate the lower limb strength generated during a countermovement jump (CMJ). Following the methodology used by Balsalobre et al. [14], subject has to perform a maximal vertical jump without using upper limbs. Applicate strength and height are measured with a scientifically validated App named "My Jump 2".

2.3.2 Range of Motion

(1) Dorsiflexion Test

This test aims to evaluate the ankle-dorsiflexion range of motion with a validated iPhone App (named: Dorsiflex App) [15]. Subject has to move into a weight bearing lunge position, to put the device with the screen touching the tibia and to do a maximal ankle-dorsiflexion as Balsalobre et al. [15] proposed in his study.

(2) Hip Range of Motion

This test aims to evaluate the active hip internal and external rotation [16]. Van Dillen et al. [16] suggested measuring hip ROM by subject lying on the plinth in prone position with the knee flexed 90 degrees having to do hip internal and external rotation. Maximal angle achieved is measured with a common inclinometer.

2.3.3 Flexibility

(1) Active Knee Extension (AKE) Test

This test aims to evaluate hamstring flexibility [17]. Subject lying on the plinth in supine position with 90 degrees of hip flexion has to extend the knee as much as possible and maximal angle achieved is measured with a common goniometer as Hamid et al. [17] did in this study.

(2) Thomas Test

This test aims to evaluate the quadriceps flexibility [18]. Following the Harvey et al. [18] methodology, the subject sits on the end of the plinth; rolls back on to the plinth, and holds both knees to the chest. The subject lowers the tested limb towards the floor. The knee angle difference between initial and final position is measured with a common goniometer [18].

2.3.4 Motor Control

(1) Drop Jump Test

This test aims to evaluate the knee valgus-angle during a single leg landing. As Munro et al. [19] did, subject has to land from a 30 cm height box with a single leg. The maximal knee valgus-angle during the landing is measured using Kinovea software [19].

(2) Single Leg Squat Test

This test aims to evaluate the knee valgus-angle during a single leg squat. Subject has to do a single leg squat and the maximal knee valgus-angle during the task is measured using Kinovea software following the protocol by Munro et al. [19].

(3) Y Balance Test

This test aims to evaluate the neuromuscular control of the lower limb and has been scientifically validated for this purpose. Following the methodology used by Shaffer et al. [20], subject stands on the centre

footplate with a single leg. While maintaining single leg stance on one leg, the subject reaches with the other leg limb in the anterior, posteromedial and posterolateral directions. The maximal distance achieved on each direction is measured with a single meter [20].

Moreover, field position, height, weight and BMI were recorded.

Variables were measured bilaterally so the total sample was $n = 50$ except for anthropometric measures and countermovement jump, the sample was $n = 25$.

2.4 Statistical Analyses

SPSS v. 20 was used for the statistical analysis. Quantitative variables and differences are expressed as mean, standard deviation (SD). Level of significance was set at $\alpha = 0.05$ and the limits of confidence interval at 95%. The suitability of using parametric or non-parametric test was verified by the Shapiro-Wilk test. The comparison between right and left side was performed using paired simple t -test or Wilcoxon test, according to the type of variable used. The correlation analysis was performed using the Pearson correlation coefficient or Spearman's rank correlation coefficient.

3. Results

The results were divided in three different parts. Clinical characteristics mean, differences between sides and correlations with significant differences.

3.1 Clinical Characteristics

Table 1 shows the mean, standard deviation, minimum and maximum of each variable measured. Results of these analyses and this clinical implication will be commented in the discussion section.

3.2 Differences between Sides

On this section, there are just unilateral variables so anthropometrics measures and countermovement jump are not included. Statistically significant differences

Table 1 Characteristics of the participants.

Variable	No.	Minimum	Maximum	Mean \pm SD
Height (m)	25	1.61	1.92	1.78 \pm 0.07
Weight (kg)	25	59.3	81.8	68.81 \pm 5.76
BMI	25	19.66	24.02	21.73 \pm 1.33
Dorsiflexión (°)	50	28.0	50.0	37.96 \pm 5.21
My jump height (cm)	25	27.20	46.02	33.92 \pm 4.82
Ake test (°)	50	120	180	139.04 \pm 13.27
ROM hip Internal rotation (°)	50	15	55	34.66 \pm 9.95
ROM hip External rotation (°)	50	26	60	41.54 \pm 7.21
Thomast test (°)	50	-2	10	4.10 \pm 2.77
Drop jump test (°)	48	141	174	158.33 \pm 8.48
Single leg squat test (°)	50	115	177	154.90 \pm 14.22
Triple hop (m)	50	5.3	7.2	6.14 \pm 0.40
Y balance (cm)	50	73.33	96.67	84.83 \pm 5.09

No.: number; SD: standard deviation; cm: centimeter; m: meter; °: degrees; kg: kilograms.

Table 2 Difference between sides.

Variable	Right side mean \pm SD	Left side mean \pm SD	Difference between side mean \pm SD	<i>p</i> value
Dorsiflexión (°)	37.19 \pm 5.17	39.03 \pm 5.45	1.83 \pm 3.23	0.009*
Ake test (°)	138.80 \pm 13.57	139.28 \pm 13.23	0.48 \pm 9.57	0.871**
ROM Hip internal rotation (°)	37.36 \pm 10.25	31.96 \pm 9.06	-5.40 \pm 7.40	0.001*
ROM hip external rotation (°)	40.12 \pm 7.44	42.97 \pm 6.81	2.84 \pm 8.59	0.112*
Thomast test (°)	3.28 \pm 2.52	4.92 \pm 2.81	1.64 \pm 2.95	0.012**
Drop jump test (°)	156.96 \pm 9.35	159.71 \pm 7.46	2.75 \pm 10.97	0.232*
Single leg squat test (°)	154.08 \pm 13.04	155.72 \pm 15.54	1.64 \pm 19.17	0.673*
Triple hop (m)	6.16 \pm 0.42	6.13 \pm 0.39	-0.03 \pm 0.39	0.742*
Y balance global (cm)	85.40 \pm 5216	84.26 \pm 5.04	-1.13 \pm 4.97	0.265*

**t* Student test; ** Wilcoxon test; SD: standard deviation; cm: centimeter; °: degrees.

were found for HIP internal rotation (mean = 5.40°; *p* value = 0.001), Thomas test (mean = 1.64°; *p* value = 0.012) and ankle dorsiflexion (mean = 1.83°; *p* value = 0.009) between both sides. However, no statistically significant differences were found for AKE test, HIP external rotation, drop jump test, single leg squat test, triple hop test and Y balance test. These results are shown in Table 2. The clinical implication of these data will be discussed in the discussion section.

3.3 Correlations Analysis

Dorsiflexion test showed a positive correlation with the ROM Hip Internal rotation ($r = 0.347$, $p < 0.016$) and with the Triple Hop test ($r = 0.385$; $p < 0.007$). On the other hand, hip internal rotation ROM showed a positive correlation with the Thomas Test ($r = -0.303$;

$p < 0.033$) and with the Single Leg Squat Test ($r = -0.371$; $p < 0.008$). Finally, the Drop Jump Test showed a positive correlation with the Single Leg Squat Test ($r = 0.298$, $p < 0.039$).

4. Discussion

4.1 Clinical Characteristics

4.1.1 Strength

Strength deficit has been described as a potential risk factor to develop sport injuries [7]. The sample of this study had a mean of 33.92 cm and 6.14 m on CMJ and triple single-hop test respectively.

Studies have measured countermovement jump height in soccer young players showing means around 38 cm [21], all of them higher than the value of this

study. Eliakim et al. [22] found that players who got injured during the season, jumped 36.8 cm in the preseason screening test. Furthermore, players who did not get injured during the season jumped 39.4 cm in the preseason screening test [22]. Thus, the sample of this study has poor values in CMJ height and maybe they are at a high risk of injury.

About the triple hop test, values shown in this study agree with the literature. Studies have found values around 6.34 m for this test [23]. No studies recording injuries in relation with triple single hop test values were found.

CMJ and triple hop test are important and useful measures to detect players at risk of injury and to propose specific injury prevention programs. Values from this study could be used as normal values for future research about this specific population.

4.1.2 Range of Motion

Many studies have shown an ankle dorsiflexion deficit as a high risk factor to develop injuries as hamstring injuries [24] or ACL injuries [25]. Mason-Mackay et al. [25], in his systematic review, showed that reduced ankle dorsiflexion could alter landing biomechanics, and this predispose player to injury.

The sample of this study had an average of 37.96° ankle dorsiflexion. Studies found norm values around 45° ankle dorsiflexion so the sample of this study is below the average and maybe the subjects have risk of injury [26]. Noronha et al. [27] did an ankle injury risk factor revision and they found that players with an ankle dorsiflexion of 34° are five times more likely than the others with 45° ankle dorsiflexion to injure his ankle.

A limited hip range of motion has been described as a risk factor to develop injuries as low back pain [16] or groin pain [11]. The sample of this study has an average of 34.66° and 41.54° internal and external rotation respectively.

Regarding the literature, Hogg et al. [28] found an average of 26° and 35° internal and external rotation

respectively for soccer players, as norm values. However, this study was about adult professional soccer players and it could be different from youth soccer players.

Thus, to measure hip and ankle dorsiflexion range of motion achieve to detect injury risk and to carry on specific injury prevention programs. Moreover, values shown in this study could be served as reference values for future studies in soccer young players where the literature is limited.

4.1.3 Motor Control

Nowadays, the evidence suggests that poor or abnormal motor control and lower limb biomechanics during sporting movements such as landing or squatting is the principal contributor to develop injuries as ACL injuries in soccer [29]. Dynamic knee valgus is one of the most accepted modifiable risk factors to have a severe knee injury and it is the most common ACL injury mechanism [29]. Two dimensional video assessment of frontal plane dynamic knee valgus is a useful and validated tool to measure poor valgus control during athletic tasks [19].

In this study, the maximum valgus angle between (1) anterosuperior iliac spine, (2) middle of the patella and (3) ankle point between malleolus was measured. A perfect alignment between these three points, that is to say, an angle of 180°, would be the optimal. However, the sample has an average of 158.33° and 154.90° (Drop Jump and SLS test respectively).

On the other hand, Y balance test which aims to evaluate balance and motor control and some studies has demonstrated this validity to predict injuries [20]. This study shows an average of 84.8 cm on the global Y balance test score. Some authors have found reference values around 79.76 cm in military population [20], 100.7 cm in basketball players [30] and 92.8 cm in soccer young players [31], which seems very close to values from the sample of this study.

In conclusion, subjects from this study have a poor motor control during landing and single squatting.

However, Y balance values seem to be next to the norm. As commented before, poor motor control is associated with ACL injury risk so it is crucial to identify poor motor control, for example with these tests, and to work specifically to improve it on specific prevention programs.

4.1.4 Flexibility

Thirty-one percent of all soccer injuries are muscle injuries [32]. Many studies have shown that muscle tightness can be a potential risk factor to develop a muscle injury [33]. Specifically, Witvrouw et al. [10] examined 146 male professional soccer players and found that preseason hamstring and quadriceps muscle flexibility testing can identify these players with high risk to develop hamstring and/or quadriceps injuries. On the other hand, Henderson et al. [34] demonstrated that these professional soccer players with lower hamstring flexibility had roughly a 30% higher risk to develop a hamstring injury.

This study's values showed a mean of 139° on AKE test and a mean variation from the initial to the final position of 4.1° on the Thomas test. Studies have found healthy adults norm values of AKE test around 148° [17], which seems close to this study values. Specifically in soccer, Van Dyk et al. [35] found an average of 168° on AKE test in adult soccer players. Regarding the study from Van Dyk et al. [35], the sample of this study has poor hamstring flexibility; however, it could be explained because this study sample is young soccer players.

To measure hamstring and quadriceps flexibility is a good way to identify player with high risk of injury and asses to develop specific injury prevention programs.

4.2 Differences between Sides

The inter-limb asymmetries have been widely studied within the literature. Range of motion, strength, motor control or flexibility asymmetries have been associated with injury risk [36].

4.2.1 Strength

Some authors have studied strength asymmetries as

possible risk factors to have an injury or reinjury [37]. Paterno et al. [38] demonstrated that people who have less than 98.5% of symmetry between sides in a triple hop test have a high risk to reinjure. Kyritsis et al. [39] showed that athletes with a difference between sides $> 10\%$ in different hop tests are four times more likely to reinjure. Haitz et al. [40] showed symmetry norm values of triple hop test in athletes around 98.6%. In the triple hop test for distance, the sample of this study had a difference between sides of 0.03 ± 0.39 [mean \pm SD] so they are at good strength symmetry parameters.

To evaluate strength asymmetries is a good way to identify risk factors that should be worked on specific injury prevention programs.

4.2.2 Range of Motion

Nguyen et al. [41] studied hip ROM asymmetries in young females soccer players. They concluded that asymmetries could cause an altered activation pattern on hip muscles [41]. Thus, hip ROM asymmetries could cause a failure on hip stabilization and this could have an implication on ACL injury. Hip internal rotation ROM significant differences between sides were observed in this study (p value = 0.001), but no differences on hip external rotation were observed.

On the other hand, ankle dorsiflexion ROM asymmetries have demonstrated its importance on injury prevention within the literature [15]. Teyhen et al. [42] observed that people with $> 6.5^\circ$ asymmetry between sides on ankle dorsiflexion are four times more likely to develop an injury. Significant differences (p value 0.009) between sides were observed on ankle dorsiflexion range of motion in this study. The difference average was $1,83^\circ$, it means a 4.82% of asymmetry.

ROM asymmetries could cause altered muscle activation patterns so it must be assessed to develop specific injury prevention programs. Regarding the data of this study, young soccer players should improve hip and ankle ROM and symmetry as part of injury prevention, specifically hip internal rotation

ROM and ankle dorsiflexion.

4.2.3 Motor Control

Dai et al. [43] and Paterno et al. [44] studied the knee kinetics asymmetries after anterior cruciate ligament reconstruction showing that it was a possible explanation of the high reinjury ratio after de return to play (ranging 6% to 27%). Fortunately, the sample of this study did not show statistical differences between sides in any of the motor control test.

To evaluate the motor control symmetry allows identifying players with high risk of injury or reinjury so it should be part of the specific injury prevention programs.

4.2.4 Flexibility

Flexibility asymmetries have been negatively associated with lower limb injury within the literature ([37, 45]). Soccer players usually favour one particular leg for kicking, passing or jumping. This could cause flexibility imbalance which is believed to predispose players to injury [46].

This study found significant differences between sides in quadriceps flexibility (Thomas test) (p value = 0.012). However, no differences were observed on hamstring flexibility by the AKE test. Regarding the data from this study, young soccer player's flexibility symmetry should be measured and worked specifically.

In conclusion, injury prevention programs should keep in mind possible asymmetries. It is really important to evaluate symmetries between sides and to work it specifically on injury prevention.

4.3 Correlation Analysis

Dorsiflexion showed a positive correlation with the Triple Hop ($r = 0.385$; $p < 0.007$). A good ankle dorsiflexion range of motion is needed to generate force against the ground while the player is hopping. This correlation suggests that if somebody wants to improve his hopping strength, he must have an optimal ankle dorsiflexion range of motion. To have a limited ankle dorsiflexion could avoid a hop strength

improvement. In conclusion, to improve the lower limb functional strength, a good ankle dorsiflexion is necessary.

The Hip Internal rotation ROM showed a positive correlation with the Thomas Test ($r = -0.303$; $p < 0.033$). This correlation suggests that hip internal rotation ROM could be influenced by quadriceps flexibility. It is important to keep in mind quadriceps flexibility to improve hip range of motion on a specific prevention program.

The Drop Jump Test showed a positive correlation with the Single Leg Squat Test ($r = 0.298$, $p < 0.039$). Both of them measure the same so it is normal they correlate. However, this correlation is useful to say that only one of them is enough to evaluate the dynamic valgus during a specific task. Maybe the drop jump is a more functional task so it is proposed to choose it.

4.4 Limitations

The principal limitation of this study is the short size of the sample. It would be interesting to know if values obtained from this study are the same with a larger size. Moreover, in this study there is no follow up because it is a cross-sectional study. It is a limitation and it would be interesting to know if values change throughout the preseason period.

5. Conclusions

This study aimed to evaluate clinical characteristics from young soccer players and to discuss about his implication on injury prevention. In order to develop specific and effective injury prevention programs, it is necessary to measure parameters as strength, flexibility, motor control or range of motion. If it is not measured, the injury prevention is widely unspecific and it is not working by the time. As commented before, soccer is an asymmetrical sport. Thus, to identify asymmetries is very interesting on soccer injury prevention and it gives crucial information to develop specific programs. On the

other hand, in order to improve some parameters such as functional strength, range of motion or dynamic knee valgus control, correlations shown in this study should be kept in mind.

Finally, this study showed specific values for semi-professional youth soccer players and injury risk associated to this data have been widely explained. Coaches, athletes and researchers may use it to compare with their own sample or soccer players. Moreover, youth soccer teams physical trainers and physiotherapists may develop specific injury prevention programs focussing on neuromuscular deficits shown in this study.

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