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Evaluation of foot support in rugby players: a baropodometric analysis

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Abstract Intense sports practice has effects on normal locomotion which may predispose athletes to certain injuries. The aim of the study was to evaluate weather playing rugby can change the distribution of forces on the surface of the foot plantar region and if these possible changes are caused by the high loading and the postural stances that this sport involves. The evaluation was performed using a baropodometer in static and dynamic conditions. We studied a group of 23 professional rugby players (scrums and three-quarters) who regularly trained 4-times per week. A control group consisted of 17 non-athletic healthy subjects. Baropodometric analysis revealed significantly higher rear-foot surface area and pressure for both feet in static conditions in rugby players compared to controls. In dynamic conditions, rugby players exerted a significantly higher ground pressure with respect to controls. Within the group of rugby players, scrums had significantly higher pressure than three-quarters, as well as a pressure increase in the lateral foot area. We conclude that rugby players tend to adopt an unbalanced posture posteriorly. The higher ground pressure together with the prevalent load on the lateral foot area may be associated with a difficult control of foot stability, possibly due to the higher body weight and to the increased tone and trophism of the triceps surae subsequent to the various athletic gestures that the game demands. In agreement with the literature, the variations of foot support observed in rugby players may be associated with adaptations induced by this sport, thus favoring an increased risk of bone, joint and muscle traumas and pathologies.

Key words Foot • Baropodometer • Rugby • Posture

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Introduction

Intense sport practice has effects upon normal locomotion thus making it possible to identify a specific gait for each sport [1]. These differences are likely to be associated with the type of activity requested due to the specific loads, the involved muscles, and the postural adaptations requested by each sport discipline.

The characteristic locomotion observed in the adults is acquired between the ages of 7 and 9 years [2]. Nevertheless, sportive subjects, especially those reaching a high level, usually begin their activity before completing the maturation of locomotion. In addition, intense training implies learning of automatic movements whose performances become stereotyped. The motor program requested is invariably different according to the sport that is chosen. The practice of some sports, like football, tennis, basketball and rugby, requests a high grade of postural balance as well as rapid directional changes. Postural stability is necessary in order to avoid falls during the performance of such activities [2].

Leroy et al. [3] have shown evidence of variations of foot support in subjects who practice sports intensely. Such differences are related to the performance model, in that there are specific loads and postural adaptations for each sport discipline. The intense practice and the specificity of sports influence normal locomotion, producing differences even among sports or among sportive and sedentary subjects [3].

Anatomical or biomechanical variations and anomalies of the joints represent risk factors that may favor accidents in many disciplines [4, 5]. There is a relationship between foot shape, its function and accidents, especially due to functional overload [1, 6–11].

Rugby is certainly one of those disciplines at risk for these kind of problems. Lee et al. [12] reported the possibility of prevention by means of evaluating the physical conditions of the rugby player, also considering those risk factors that are intrinsic for the discipline. Among the latter, we can include defects in axiality, distribution of body weight at ground and generally, posture.

The aim of this study was to evaluate if the professional practice of a sport like rugby can cause changes in the sole arch and if these modifications are caused by the high loading and the postural stances that this sport involves. In addition, considering that there are marked differences in the performance model of the athletes according to the sport, we investigated differences among rugby players, especially regarding the role they played in the team. The study considered the evaluation of the foot support both in static and dynamic phases using an electronic baropodometer.

Subjects and methods

Two groups of subjects were evaluated. A control group consisted of 17 male students of physical education from IUSM (Rome, Italy), who practiced various non-competitive sport activities. Their mean age was 25.9±1.8 years (range, 22–30 years), and they had no history of foot pathology or alterations. The rugby players group consisted of 23 professional rugby players from the First (n=6) and Second (n=17). Divisions of the Italian league. Their mean age was 24.0 years ±3.9 (range, 16–32 years) and they had played sports for 10.7±3.5 years. The rugby players were subdivided by team roles: 12 scrum and 11 three-quarters players. Players acting in different roles use different footwear. Since scrum players need maximum foot support on the ground, they use boots with a few (generally 8) long studs. Three-quarters need a boot that is better adapted to directional changes; therefore, they use boots with 13 smaller studs. Furthermore, scums have higher ankle biomechanical requests and higher body weight, making them use a taller boot at the ankle. Besides the official game on Sundays, the rugby players were undergoing four training sessions weekly lasting two hours each for ten months a year.

Study protocol

All subjects underwent an electronic baropodometer test, in static and dynamic (locomotion) conditions without footwear. We used a module-platform electronic baropodometer (Physical Support, Rome, Italy) with a 120-cm long and 40-cm wide barosensitive platform. The board contains 4800 platinum electronic sensors covered by an alveolar rubber captor that gives pressure information from each foot to an electronic elaborator. During static conditions, the subjects stood on the platform in an orthostatic position for 10 s. In dynamic conditions, the subjects walked on the board during data collection. The following parameters were considered in static condition: support surface areas of both feet; the percentage distribution of load between rearfoot and forefoot; and the pressure exerted upon the medial and lateral portions of each foot. In dynamic conditions, we assessed support surface areas of both feet and pressure exerted, on the ground

In static conditions, the baropodometer allows one to visualize the center of gravity "C" and the pressure centers of the single limbs. In order to use this instrument correctly, the pressure center must be placed centrally to the medial part of the foot; an eventual misalignment indicates a possible postural anomaly. Load distribution should be, under normal conditions, uniform and equally distributed between both support surfaces, and 40% of the load should burden the forefoot and 60% the rearfoot. To obtain a clear and simple visualization of the areas of foot support during the static phase, the imprint is elaborated as isobars, thus obtaining a point-to-point map in the single areas of pressure at the various levels of load. In dynamic phase, the baropodometer allows the visualization over time of normal gait.

Statistical analysis

The statistical analysis was carried out using Student's t test, considering a p value <0.05 as significant.

Results

We studied the distribution of forces on the foot in 17 healthy control subjects (non-athletes) and in 23 professional rugby players (Table 1). Control subjects were shorter and lighter than rugby players and had higher body mass index (BMI). Among rugby players, scrums were heavier and had higher BMI than three-quarters.

At baropodometric analysis in static conditions, the support suface area of the rearfoot was significantly greater in

Table 1 Physical characteristics of the control and the rugby player group

	BMI, kg/m^2	Weight, kg	Height, cm
Controls	23.03 (1.38)	71.12 (6.15)	177.4 (4.8)
Rugby players	26.22 (3.28)*	87.35 (13.12)*	182.2 (6.2)*
Scrums	28.03 (3.23)†	95.67 (12.96)†	184.5 (6.5)
Three-quarters	24.24 (1.96)	78.27 (4.52)	179.7 (5.1)

* p<0.05 vs. controls; † p<0.05 vs. three-quarters

rugby players than in controls, but there was no significant difference in forefoot area (Fig. 1ac). Concerning load distribution between forefoot and rearfoot expressed as percentages, there was a significant difference between groups regarding the left foot but not the right foot, with a greater distribution towards the left forefoot in control subjects (Fig. 1b). Finally, regarding pressure exerted on the medial and lateral portions of the feet, there was a significant difference

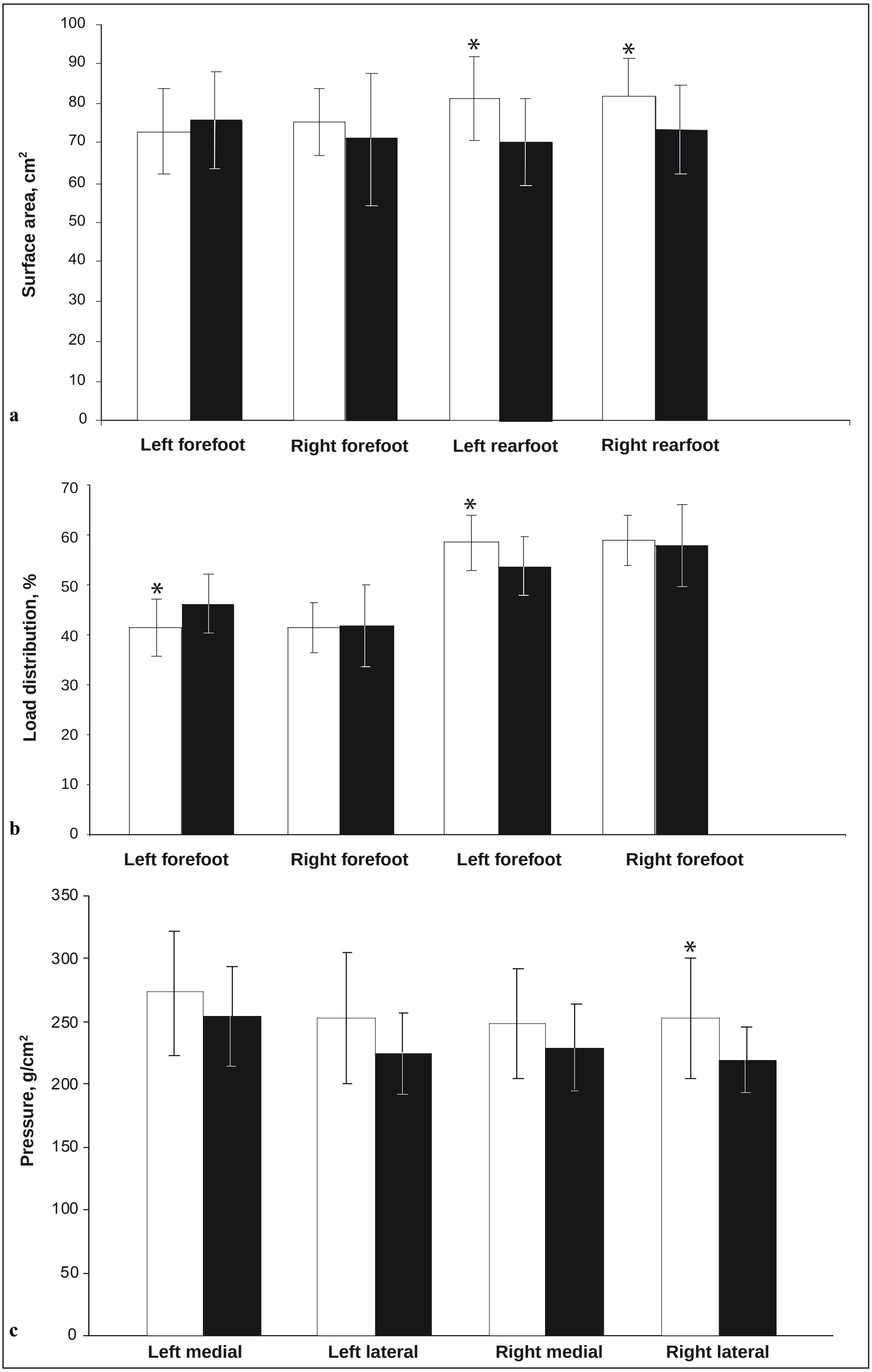

Fig. 1a-c *Baropodometric parameters of forefoot and rearfoot in static conditions (standing), for 23 rugby players and 17 healthy control sujects*. **a** Support surface area. **b** Load distribution between forefoot and rearfoot. **c** Pressure on medial and lateral portions of the feet. *White bars*, rugby players, *black bars*, controls. Values are means and SD. * $p < 0.05$ vs. controls between groups only regarding the right lateral portion, which was greater in rugby players (Fig. 1c).

Baropodometric analysis revealed significant differences between rugby players and controls during dynamic conditions (walking). In particular, the rugby players had significantly greater surface support (Fig. 2a) and pressure (Fig. 2b).

When we compared rugby players according to the role they played on the team (scrums and three-quarters), we noted that in static condition there was a significant difference regarding the mean pressure exerted on the medial and lateral portions of both feet: scrums had clearly higher values than three-quarters (Fig. 3a). During dynamic conditions, pressure values in scrums were significantly higher than those obtained in three-quarters (Fig. 3b).

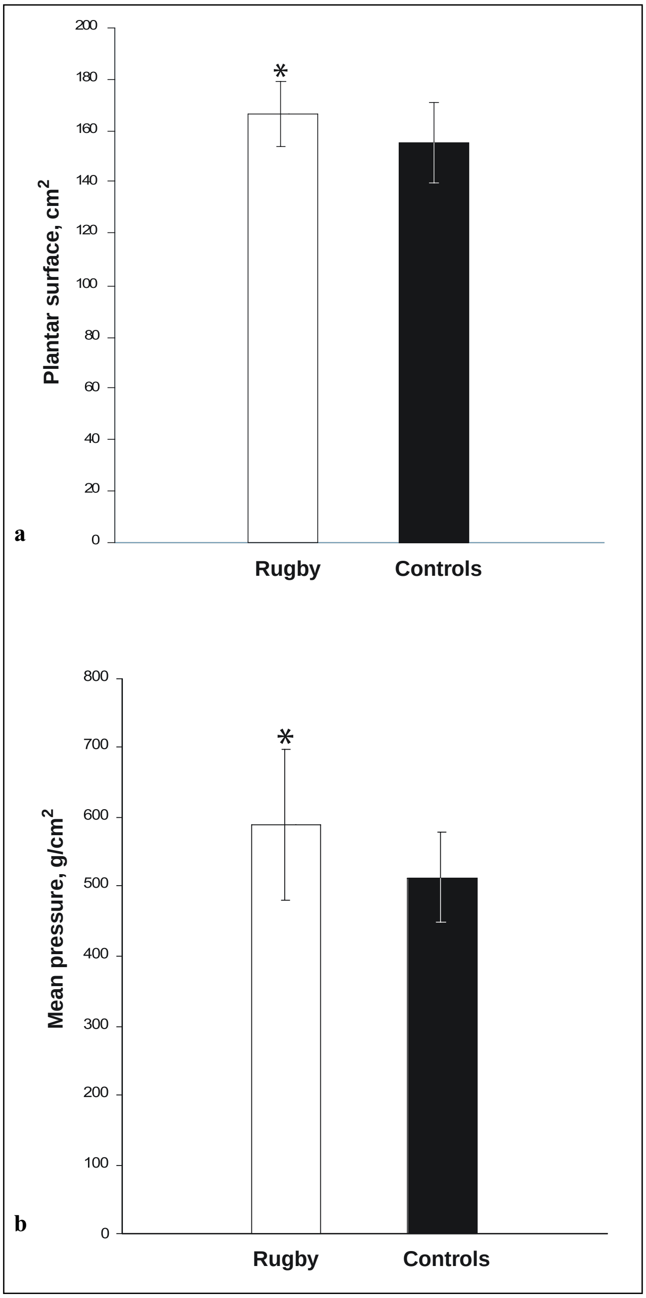

Fig. 2a, b *Baropodometric parameters in dynamic conditions, by study group*. **a** Plantar surface. **b** Pressure exerted on the ground. *White bars*, rugby players; *black bars*, controls. Values are means and SD. *$p<0.05$ vs. controls

Discussion

In static conditions, there were significant differences between rugby players and controls regarding the rearfoot surfaces of both feet. This fact likely suggests a posteriorly unbalanced global posture in rugby players. This was apparent even from the simple visual assessment of sole imprints: most rugby players did not evidence toe prints. We thus conclude that the performance model of this sport influences the posture of players.

Another significant difference regards the load distribution of the left forefoot where, in contrast to what observed for surface area, the control group had higher values. This fact supports our hypothesis that rugby players' posture may be drawn back with respect to controls.

The right foot of rugby players was supinated in static conditions when compared with controls, and the pressure was significantly higher in the right lateral area. Soames [13] reported that an increase in body weight increases the difficulty of controlling lateral foot stability, with subsequent higher pressures on the lateral vs. medial portion. A further explanation of this tendency to foot supination in rugby players is an increase in muscle tonus and trophism due to the special requests of this sport: it is well-known that the action of the triceps surae determines a rearfoot inversion with stiffness of the tarsal joints and supination of the whole foot [14].

In dynamic conditions, rugby players exerted a significantly higher pressure to the ground with respect to controls. Rugby has a performance model with heavy loads on the lower limbs, and thus upon the feet, due to either usually higher body masses and due to both the necessity to produce actions of keeping the feet fixed on the ground and pressing by jumps or by movement changes. This may also explain the modifications in normal locomotion that is characterized by high pressures; this is also supported by the fact that foot surfaces were significantly larger in rugby players in dynamic conditions.

When the two different rugby roles, scrums and three-quarters, were compared, significantly higher values were revealed between pressure values in both feet of scrums in both static and dynamic conditions. This finding may be explained first by the different physical structure of scrums, clearly heavier, and second, by the different performance that is needed. Furthermore, scrums use a different boot shape than three-quarters, and this may have an additional effect.

The risks of bone, joint and muscle overload-related trauma and pathologies have been reported to be high in rugby players [3, 15–18]. Our findings of foot support anomalies in rugby players with respect to controls gives further

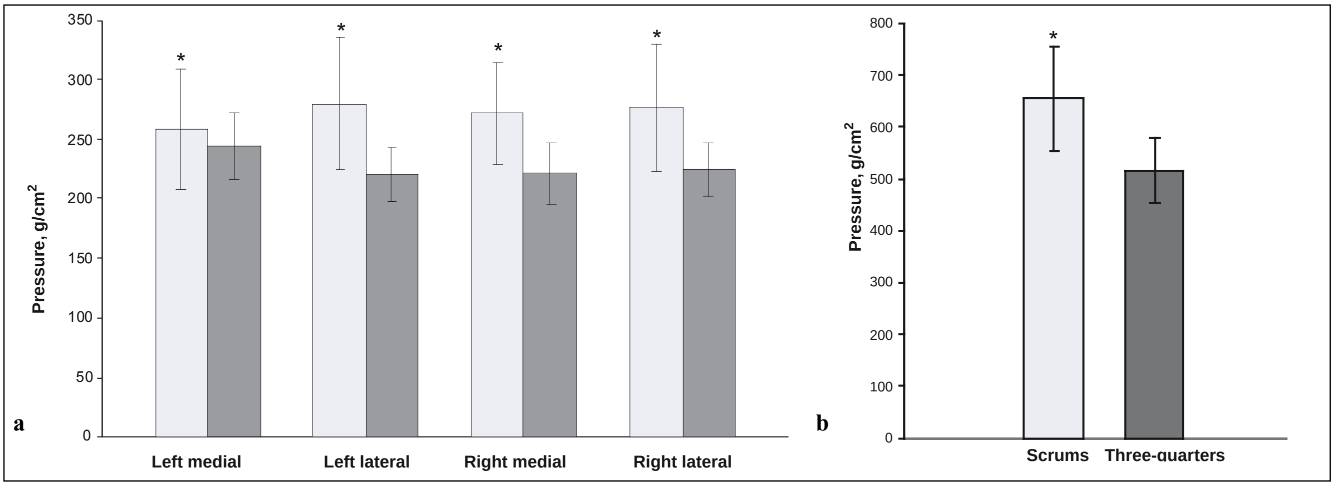

Fig. 3a, b *Baropodometric parameters of rugby players, by role on team*. **a** Pressure on medial and lateral portions of the feet in static condition. **b** Pressure exerted to the ground during locomotion (dynamic condition). *Light gray bars*, scrums; *dark gray bars*, three-quarters. Values are means and SD. *$p<0.05$ vs. three-quarters

support to this hypothesis. In addition, the type of performance of this discipline may give rise to particular postures due to poor control both on the anteroposterior (rearfoot overload) and frontal (foot supination) planes.

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