Playing intensively a sport involves a specific gait pattern.

Leroy D.[1,2], Polin D.[1], and Weber. J.[1]
[1] GRHAL (Research group on gait disorders), CHU Rouen, 76031 Rouen Cedex.
[2] CETAPS, UFR STAPS, Université de Rouen, 76821 Mont Saint Aignan Cedex.

Introduction

Gait and posture are both controlled by motor programs that are partly genetically determined and partly learned. Locomotion may be regarded as a program which uses a combination of both. Sedentary adults have an automatic, alternate bilateral, totally symmetric, and reproducible locomotion (Murray et al., 1964). Intensive sports training involves learning automatic movements. The execution of these movements has to become stereotyped and reproducible. The motor programs required are inevitably different from one sport to another. The playing of some sports such as soccer, tennis or basketball, demands a high degree of postural balance and quick movement programs. In a previous study, it has been shown that the locomotion of sportsmen practicing intensively preferentially unilateral sports, such as basketball and fencing results in the development of some asymmetrical gait variables (Leroy et al., 1998). In right handed high level fencers and basketball players, the main difference was that the right propulsion double support duration was found to be longer than the left one. Basketball and soccer are to some extent a unilateral sport. A right handed basketball player has most of the time a right-left lay up (83 %) (Azémar, 1998). A right handed soccer players usually uses his right foot to shoot and dribble the ball, and his left foot to support the body before a jump or a shoot. Swimming is essentially a bilateral activity. Whatever the swimming style used, the two segments of the lower or upper limbs reproduce almost the same symmetric movements, simultaneously or alternatively according to the style.

The aim of our study was to evaluate whether an intensive sport activity can have any effect upon the normal walking. If so, have these sportsmen a sport-specific gait pattern? Gait variables of a preferentially unilateral handtool activity (basket-ball), of a preferentially unilateral foottool activity (soccer) both using locomotion and of a bilateral activity not using locomotion (swimming) were compared.

Method

Studied population

Thirty-six right handed male subjects (10 basketball players, 10 swimmers and 16 soccer players) were recruited during a medical check. They accepted their gait to be recorded. Since they were all athletes, a sports physician checked that no players had any problems. Handedness was checked by the “Edinburgh Handedness Inventory” which permitted distinction between absolute, preferential or ambidextrous right or left handedness. Ten swimmers aged 20.0 ± 3.6 (M±SD), ten basketball players aged 22.9 ± 7.4, and 16 soccer players aged 23.0 ± 3.0 were included in this study. Use of an ANOVA test failed to indicate any statistical difference between the three groups for the ages, weigths and heigths. They were all competing at national level. They had all played for at least 5 years, 8 hours a week. All of the athletes were male and righthanded. Basketball players were all preferentially jumping with their left leg, whereas soccer players were all shooting with their right foot (being on a left stance) . Swimmers used either a crawl or butterfly stroke.

Material

The apparatus developed by Bessou and al. (Bessou et al., 1988) simultaneously records longitudinal displacements of both feet during walking. Each foot is secured to a non-elastic rope, which is wrapped around a pulley system connected to a potentiometer. After reduction by the pulley system, displacements of each foot cause rotation of the axis of the potentiometer, which receives a direct current. The signal is produced by changes in voltage over time. The voltage delivered by each potentiometer is proportional to the distance traveled by the foot to which it is attached. The acquired signal is converted by a computer (200 Hz) and analyzed with a specific software allowing measurement to the nearest 5 mm and timing to the nearest 5 ms. Figure 1 shows a reference gait recording. Bessou’s gait analyzer permits simultaneous recording of the longitudinal displacements of both feet during the gait. Thus spatial (stride length and step length), temporal variables (cycle, stance, swing and double support durations), and walking speed

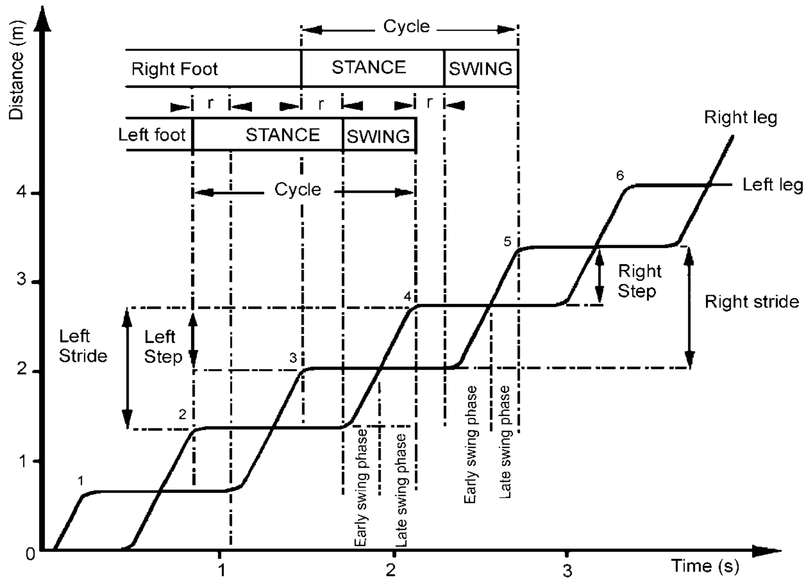

Figure 1: Reference gait recording obtained with the Bessou gait analyzer. Each curve represent the movement of one leg. "r" means propulsion double support duration.

were characterized. The right propulsion double support duration is the same as the left loading double support duration. Each subject was instructed to walk from the apparatus to an object placed at the end of the recording distance (seven meters), at their normal speed, striking out with the right foot and pulling on the wires to activate the apparatus. Each subject was recorded twice; the first recording was used to make the athletes familiar with the device, and these initial data were not used.

Statistic analysis

The Student's t test for paired data has been used to compare quantitative variables between right and left sides of each group of subjects. ANOVA was used to compare quantitative variables between basketball players, swimmers and soccer players. Values of p under 0.05 were considered significant. Finally, one discriminant analyses was performed on the 36 subjects of the three groups with all the gait variables.

Results

Analysis by sport group.

	Basketball Players (n=10)		Swimmers (n=10)		Soccer Players (n=16)	
	Right Side	**Left Side**	**Right Side**	**Left Side**	**Right Side**	**Left Side**
Stride length (m)	1.56 ± 0.16	1.56 ± 0.15	1.57 ± 0.13	1.57 ± 0.13	1.49 ± 0.11	1.48 ± 0.10
Step length (m)	0.79 ± 0.08	0.76 ± 0.08	0.80 ± 0.08	0.77 ± 0.06	**0.75 ± 0.05 ***	**0.73 ± 0.05**
Cycle duration (s)	**1.26 ± 0,09 ***	**1.24 ± 0.09**	1.22 ± 0.04	1.22 ± 0.04	1.14 ± 0.06	1.14 ± 0.05
Stance dur. (% of the cycle)	62.30 ± 3.06	62.23 ± 2.76	62.74 ± 1.03	61.84 ± 2.22	62.91 ± 1.15	63.16 ± 1.23
Swing dur. (% of the cycle)	37,70 ± 3,06	37.77 ± 2.76	37.26 ± 1.03	38.16 ± 2.22	37.09 ± 1.15	36.84 ± 1.23
Prop double stance dur. (% of the stance)	**12.72 ± 3.06 ***	**10.90 ± 3.25**	12.30 ± 1.71	12.27 ± 1.15	**13.27 ± 1.13 ***	**12.36 ± 1.38**
Cadence (cycles/min)	96.2 ± 7.5		98.4 ± 3.5		105.38 ± 7.3	
Walking speed (m/s)	1,25 ± 0.13		1.28 ± 0.11		1.30 ± 0.10	

* : p<0.05 between the right and left sides.

Table 1: Spatiotemporal gait parameters of basketball players, swimmers and soccer players.

Table 1 shows mean values for spatiotemporal gait variables in each sport group. As regards the swimmers, comparing right and left sides, the Student test for paired data failed to point out any statistical difference for all variables. In the analysis of the basketball players, the right cycle duration (p=0.022) and right propulsion double support percentage (p=0.004) were found to be significantly higher than those of the left side.. In the soccer players group, the right step length (p=0.016) and right propulsion double support percentage (p=0.014) were significantly higher than the left side.

Analysis between the three groups.

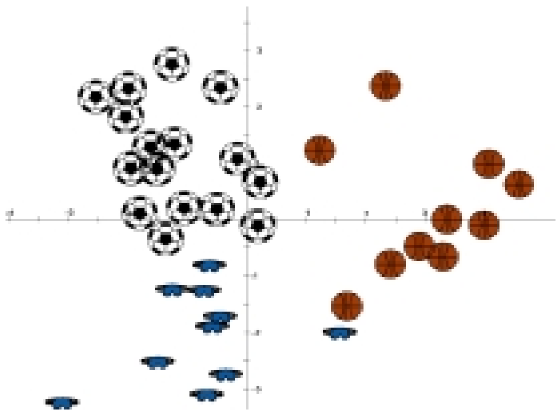
Figure 2:Discriminant Analysis performed with all gait variables

ANOVA revealed that some variables were significantly different between those of the soccer players, of the swimmers and of the basketball players. Walking speeds of the three groups were comparable whereas cadences were significantly different (p<0.001). The statistical data did not reach significant difference between the three groups for the stride length, or for the step length. Cycle durations for both sides were different between the three groups (p=0.001). The soccer players walked with a higher cadence (p=0.001 for basketball players, and p=0.015 for swimmers). When comparing the gait variables by a discriminant analysis, however, the three athletic groups present strongly different gait patterns (figure 2).

Discussion

The aim of our study was to check whether the playing of a particular sport exerted any influence on gait pattern. Murray et al. showed that walking was a highly reproducible activity in subjects younger than 60 years (Murray et al., 1964). Moreover, the gait of athletes was not different from the gait variables of sedentary subjects studied with the same apparatus in the same laboratory (Richard et al., 1995). However, despite the fact that the walking pattern of athletes is not very different from that of non athletic subjects, we still found some differences depending on the sport played.

In those engaged preferentially unilateral sports, the right propulsion double support duration was found to be longer than that of the left side, confirming a previous study (Leroy et al., 1998). However, this has not been observed in normal non athletic subjects nor was it seen in swimmers in this study. Most often, when right handed sportsmen need to perform a shoot, a dribble, a high or a long jump, the impulse side is the left foot. In this study, all the subjects were chosen righthanded, and using the left foot as the impulse foot. During a jump or a shoot, just after the right propulsion double support duration, the equilibrium of the body is based upon a monopodal left stance, while the right is swinging. Before each body movement, it is necessary to anticipate the postural equilibrium to keep a perfect balance during the jump or the shoot. The anticipatory postural adjustments (APA) occur before staring a voluntary movement. They correspond to dynamic phenomena which are centrally pre-programmed (Bouisset & Zatarra, 1987). These APA anticipate the perturbations of posture and equilibrium connected to the movement (Massion, 1992). Our results imply that the higher right propulsion double support duration could be a consequence of a particular APA programmed to be used before the shoot or the jump.

Some other variables (step length, cycle duration) were also found to be affected. Soccer and basketball are sports of movements and contact. The ball is earned or lost by a succession of sprints (soccer), accelerations/decelerations (basketball), violent efforts, jumps, and shots. These different actions not only involve some modifications of the central motor program, such as APA (Mc Ilroy & Maki, 1993), but also a particular muscular development, which could be asymmetric (Anderson & Sidaway, 1994). As regards the swimmers, during their activity in the water, their training does not involve any asymmetric muscular development, since swimming is totally bilateral.

The step lenght have been found to be statistically different between the soccer's group and the other groups. A soccer player executes smaller steps and strides during his activity. It is due to the constrains of soccer which demands to mostly have the foot in contact with the ball. In fact, the more the foot is in contact with the ball, the more the player controls the ball. Walking at the same speed (1.30 $m.s^{-1}$), but with smaller steps than the other groups, a soccer player walks with a significantly higher cadence.

In conclusion, playing sport such as basket-ball, soccer or fencing over a period of years seems to have induced some permanent differences in the locomotion pattern between right and left sides, and from one sport to another. In this study, we have been unable to clarify which were due to asymmetric muscle development, which were a consequence of the central motor program, or which were due to the combination of these two factors.

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