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Original Article

Symmetry and performance index evaluation in a youth football group using the latest generation IMU

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Abstract
Scientific research shows that during multi-directional sprints, athletes must maintain a certain degree of stability and balance during the transition from a dynamic state, to a momentarily static state to change direction, before returning to another dynamic, acceleration. An optimal dynamic balance would help to maintain a stable centre of gravity, allowing better optimization of the action times in the technical execution of the performed gesture. The role of body imbalances and their effect on the performance of linear and multi-directional acceleration will require further significant studies, especially related to the muscular and articular biomechanics of the gestures, to better clarify the personalization of performance in the different executive speeds, to establish the different commitment on the osteo-muscular system. The main aim of this study arises from the idea that a symmetrization of the sides of the body, will certainly benefit the dynamics in question. The aim is to identify the elements of symmetry of the human body and how it can be performative, in a general sense, thanks to the use of inertial sensors (IMU), which allow to obtain extremely high precision data on which to calibrate the training and performance work parameters. Data collection was performed using latest generation IMU sensors worn by the subjects using special undershirts. The research protocol was carried out on 104 young football players (average age 11.7). Two tests were performed, the first was carried out during the summer preparation (preseason, T1), the second was at the end of the football season (postseason, T2). The parameters under attention were: Training load, AVG Strength and Lateral Imbalance. The results of the comparison of the two tests were: for Training Load, 74 players (71.16%) showed a decrease and 28 an increase (26.92%) and 2 a zero variation (1.92%); for Average strength, 52 players (50%) had a decrease and 49 an increase (47.12%) and 3 a zero change (2.88%) and for Imbalance, 46 players (44.23%) showed a decrease and 58 an increase (55.77%).These three parameters, are respectively expression of force, force distribution and dynamic body imbalance provide data on the real abilities useful for optimal performance in changes of direction for each of the items investigated and therefore, they give the possibility to create more specifically adequate training programs.
Keywords: motor control, balance, performance analysis, coordination assessment

Introduction

Children and adolescents are undergoing a non-linear maturation process, characterized by growth peaks that affect their ability to learn optimally particular motor skills. Proper youth training must take into account the psychophysical peculiarities of each age range to concentrate and take full advantage of the specific age-related to motor learning of the different skills and try to expand the motor experience (Cottini 2011). Therefore, during growth, the organic-muscular capacities should be developed not to the maximum but in an optimal way as opposed to the coordinative ones which take on a highly significant value. Coordination skills rely on movement control and regulation processes, in fact, they are considered fundamental in sports activities as they allow to easily control motor actions and learn complex movements relatively quickly. The ability to balance is one of these and is a coordinative ability that develops early and has no contraindications if used at all ages including those of entry to the sport and for this reason, training must be accentuated and consequently, its analysis gave the proven usefulness in quality of the reproduction of the gesture (Fetz, 1989). During the practice of his sport, the athlete loses his balance both for "internal" and "external" causes (Weineck J., 2009) the balance capacity is influenced by various factors, such as sensory information, joint flexibility and “ROM”, range of motion (Lockie et al., 2016) and muscle strength (Grigg 1994; Nasher et al. 1982; Palmieri et al., 2002, Bishop et al., 2018) and is responsible for both the development of even complex movements revealing itself also decisive for the prevention of injuries. Talking about movement and sports gestures, it becomes essential to highlight the

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importance of the quality of postural control necessary when, in addition to the force of gravity, other forces come into play to set the whole body in motion. This is what happens in motor gestures, especially in more complex ones, such as changes of direction (CoD). Maintaining the static balance, and especially the dynamic one is particularly complex because the human centre of gravity is placed quite high and the support base is made up of the relatively small contact surface of the feet. The body, therefore, would tend to fall forward if the posterior kinetic chain did not keep it continuously in the upright position. In fact, it should be emphasized that the physiological curves of the spine and the supports provided by the thorax and abdomen collaborate with the perfect position of the body's center of gravity: hydropneumatic supports, very plastic and, for this reason, suitable for the task to be performed, as they are adaptable to the movement.

The diaphragm, on the other hand, becomes the basic element of the anterior support. It rests on the viscera and creates hydropneumatic support, which, due to its deformability, ensures the possibility of creating movement. To ensure the stability of the abdominal cavity, all the organs are inserted into the same sac (peritoneal sac), in order to make the internal pressures functional. There is a reciprocal relationship between intraperitoneal organs, diaphragmatic pressures, and the lumbar spine, which justifies maintaining the functionality of the abdominal region and, specifically, of the transverse abdominal muscle. The human body is to be considered an unstable "structure" that continuously fights against the force of gravity in order not to fall (Casadei et al., 2013). Scientific research shows that within multi-directional sprint movements, such as CoDs, athletes must maintain a certain degree of stability and balance during the transition from a dynamic state, deceleration, to a momentarily static, stop, to change direction, transfer of muscle impulses, before returning to another dynamic, acceleration. An optimal dynamic equilibrium would help to maintain a stable centre of gravity allowing a better optimization of the action times in the type of movement described (Bressel E. et al., 2007; Kovacs et al., 2008). Many studies have also reported that, imbalances in strength and power qualities can be detrimental to athletic performance (Bailey et al., 2013; Hart et al., 2014, Bazyler et al., 2014, Bailey et al, 2015;). However, the role of body imbalances and their effect on the performance of linear and multi-directional acceleration seems not yet been investigated or fully investigated. Furthermore, there is a marked lack of research investigating such imbalances in the youth population.

Therefore, research studies on young athletes can be an important tool with the aim of defining and optimizing training programs in relation to the sport practiced, the rate of improvement of equilibrium indices over time, and at the age of the athlete. Quantifying human movement during sports activities is a topic that arouses a lot of interest because it allows operators in order to evaluate the work in charge according to the performance provided and also to analyse how, for example, those characteristics inherent to the body symmetry in function develop. of the technical execution in the various age groups (Exell et al., 2016, Meyers et al. 2017). The natural development of a side preference, left-handed or right-handed, which is also clearly limiting in motor and sports performance, and can be seen in football where a player is positioned to the right or left depending on his preferred foot or on the contrary when strategy requires it, it could have a noticeable less impact on this imbalance which then reverberates on the gestural quality and performance of the athletes. The symmetrical, bipodalic training, thanks to an adequate teaching methodology, would impose itself in the optimization of the "weak" side, despite the belief that the preference would certainly remain when the individual can make a choice (Rouissi et al., 2016, Socci et al., 2020) The main purpose of this study is therefore a first screening (step) to highlight what has been described above, giving a relevant weight to technical elements such as the CoD, and how much these can allow a higher quality performance thanks to a targeted and weighted and no longer casual training. It is important to point out that the use of not a so large sample, certainly still to be expanded further, for a more systematic and more significant study, of an age group so little present in the specific literature, allows an important analysis of a phase of the training of young people, starting from which the whole concept of symmetry would present elements of greater linearity and simplification in the dynamics of training and its performance.

Means and Method

Research hypothesis

Main goals:

- check if the inertial sensors offer an accurate analysis of parameters on the body symmetry inherent to the coordinative capacity of dynamic balance during changes of direction;
- verify through a longitudinal study if and to what extent, there have been improvements or worsening of the above parameters and if the latter have been influenced by the maturation processes typical of pubertal age, with, at a later time, a detailed analysis of the didactic load of the training programs administered during the year with regard to the fundamental investigated.

The analyses carried out evaluate both the presence or absence of significant performance differences in the test, between the measurement periods taken into consideration. In the first measurement period 148 children (average age 11.5) were included, while in the second cycle 129 children (average age 11.6) were examined and, to carry out the comparison analysis as per the objective of the study, they were excluding those who, for various reasons, were not present in both survey periods. In fact, the quantitative research was carried out on 104 young footballers (average age 11.7), the data collection was performed using the latest generation IMU sensors worn by the subjects by means of a special undershirt, where the device was placed inside exactly in a pocket located on the back dorsal-cervical area (Izzo et al., 2020a, Izzo et al., 2020b). The very small dimensions (the smallest on the market, 70x20x7mm., K-Sport Uni.) and the minimum weight (13 g.) did not interfere in any way with the test performance, causing no discomfort in the execution of the movements examined. The instruments used had a sampling frequency of 100 Hz (with a maximum frequency up to 4000Hz), with acquisition on the three axes (x, y, z), of a "data buffer" of 18G and with a memory and battery life of 3 h. Once the recording of the test path was completed, the collected data were downloaded by connecting the device as a normal USB pendrive to the PC, downloading via the K-Fitness software (K-Sport Uni. Ita). Following graphic of technical path of the test (Fig.1).

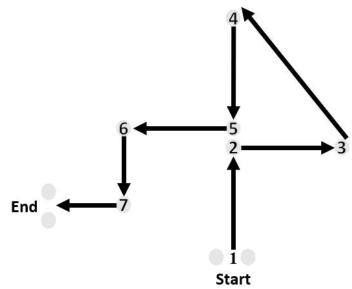

Fig.1 Test Path

The measurements of the test path (divided into segments-arrows as in fig. 1) is described as follows:
1) From the point described above (start) to point 2 = 5.50 mt .;
2) Change of direction (CoD) 90 ° to the right (dx) after 5.50 meters, point 3.
3) CoD 45 ° to the left up to point 4 (7.80 mt.);
4) CoD 45 ° to the left and back in the direction of departure up to point 5= 5.50 meters;
5) CoD 90 ° point 5 on the right up to point 6 = 5.50 mt .;
6) CoD 90 ° at point 6 on the left up to point 7 = 2.75 mt .;
7) CoD 90 ° at point 7 to the right up to path end = 2.75 mt.

For a total of 35.30 meters and 6 changes of direction. As mentioned above, the first application of the test was carried out during the summer preparation, and the second was performed later at the end of the football season. In order to build an adequate motor familiarization of the test by the subjects, a pre-test was performed one week before the first official test. During the longitudinal test, two sessions test were performed, first during the summer preparation (T1), the second at the end of the football season (T2). The protocol required to perform three evaluation for each athlete, calculating the average of them, in order to have better reliability and precision of the parameters to analyse. The parameters under evaluation are divided into:

- Training load: which expresses the workload developed. To obtain this parameter, the system uses the 3D data by the inertial sensors, which are essential for carrying out a stereoscopic analysis. It therefore provides a specific reference on the amount of effort expressed by the player. It is measured in (G = 1m / s²);
- AVG Strength: observed in parallel to the "training load", provides an average indication of the distribution of force over the training period. It, therefore, refers to what was the intensity, that is the distribution over time of the effort indicated above by the training load. It's calculated in Newton (N);
- Lateral Imbalance: shows general indications on the amount of use of the legs. At the end of a workout, it indicates which leg is more stressed than the other and how much. It is a parameter calculated using the acceleration data by transverse axis of the body. The sensor perceives variations in acceleration also due to the static position, it can therefore also be used for static tests to verify the player's postural symmetry quantifying any "body imbalance". A negative value indicates a prevalence of the left side, on the contrary, a positive value indicates a prevalence of the right side.

The raw data obtained through the IMU were analyzed using the K-Fitness software (K-sport Universal, Italy), once the data was downloaded, the software automatically calculated the measurements given by the tests and graphed them on the Cartesian system (Fig. 2). The total time (expressed in minutes) of operation of the sensor is shown on the abscissa axis, while the acceleration produced during the tests (expressed in m / s²) is represented on the ordinate axis. Thanks to the automatic detection of non-linear accelerations by the program, therefore those that occur in changes of direction, it was possible to highlight the 3 tests quite simply.

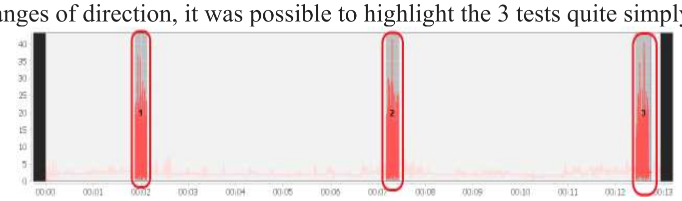
Fig. 2. Example of a test, containing the three sessions

The last step carried out was to start the software to process the three identified tests (more marked graphic oscillations) in order to calculate, through algorithms, the body symmetry parameters and to automatically transfer them to the PC in worksheets Excel in order to subsequently allow the work of statistical analysis. The statistical work began by calculating the average results between the three session for every athletes (Tab.1). This calculation work on the 3 tests conducted for each variable was carried out for all 104 athletes (Tab. 2):

Drills	T.L [G]	Avg.Strenght (N)	IMB %
1	10,5	559	7,35
2	9,1	562	14,92
3	10,4	609	18,37
Avg.	**10,7**	**577**	**13,55**

Table 1: Example of arithmetic average of the values for the 3 tests carried out by one athlete.

	First Test			Second Test		
Ath	T.L [G]	Avg.Strenght (N)	IMB %	T.L [G]	Avg.Strenght (N)	IMB %
1.	10,1	577	13,6	9,7	674	20,0
2.	13,2	728	-15,8	7,4	543	-5,6
3.	11,7	598	7,2	9,6	696	-6,2
4.	12,0	657	-12,8	10,9	536	-38,4
5.	12,8	660	18,6	11,0	696	32,5
6.	13,7	647	16,3	1,8	434	25,6
7.	10,9	575	-11,2	11,2	628	5,5
8.	11,4	614	13,2	1,7	408	26,7
9.	11,3	542	-6,1	12,0	553	-8,8
10.	10,7	575	24,2	12,6	571	17,9
11.	11,9	557	27,5	2,0	338	13,2
12.	11,6	579	-25,6	11,4	707	-5,2
13.	11,7	534	-7,2	13,1	759	18,0
14.	11,9	589	10,3	11,2	653	10,7
15.	12,1	636	9,9	11,2	617	-18,0
16.	14,7	738	4,9	2,1	394	-8,3
17.	11,1	590	12,6	11,7	695	7,7
18.	14,2	649	-9,0	11,2	691	5,8
19.	10,2	631	14,5	9,8	642	20,0
20.	13,5	718	23,8	11,0	721	4,0
21.	12,6	623	-24,0	10,6	698	-6,3
22.	12,2	676	7,7	11,0	695	5,1
23.	11,3	612	16,7	10,4	595	-6,0
24.	10,9	599	-10,8	12,4	709	28,8
25.	11,0	627	15,5	9,6	596	8,0
26.	10,5	560	-15,1	9,4	577	5,1
27.	12,2	568	7,5	11,6	712	16,1
28.	12,6	644	-9,1	13,9	696	7,3
29.	9,7	582	-26,3	10,8	660	14,3
30.	10,3	661	-4,8	12,5	707	15,1
31.	13,1	636	-7,1	11,4	690	-5,6
32.	11,4	648	3,7	12,3	692	4,4
33.	12,6	800	3,4	10,7	761	-7,8
34.	10,6	604	7,6	1,7	392	-19,8
35.	11,0	542	17,6	10,2	624	-5,2
36.	10,8	736	13,6	9,4	628	13,4
37.	11,2	594	21,6	12,0	743	14,6
38.	11,1	525	-11,5	12,5	630	-18,4
39.	10,6	573	11,6	1,7	379	15,4
40.	12,2	637	-9,0	12,0	721	8,9
41.	10,2	548	33,0	1,6	374	8,3
42.	13,1	612	20,3	1,6	385	11,1
43.	11,2	612	30,5	8,9	547	-5,2
44.	11,3	668	9,6	11,9	719	-7,6
45.	13,4	708	4,9	11,8	720	7,3
46.	12,2	542	10,6	9,9	520	2,2
47.	10,1	594	-11,3	11,0	642	14,0
48.	11,9	542	1,2	10,7	668	10,9
49.	10,6	585	17,8	10,4	603	-9,2
50.	12,4	648	15,0	12,6	681	-12,2
51.	13,0	562	-25,4	10,7	631	-9,0
52.	9,9	547	-25,9	1,7	342	-20,1
53.	12,5	745	-3,3	11,4	727	5,2
54.	13,7	594	-17,1	9,3	526	-6,8
55.	12,3	609	-16,2	1,6	369	14,8
56.	14,7	604	-2,4	13,9	695	-19,8
57.	12,6	652	27,9	10,7	575	7,3
58.	10,1	632	3,7	10,2	599	-9,0
59.	10,5	765	6,0	11,7	690	-8,5
60.	10,5	765	-6,0	12,2	661	3,3
61.	12,3	711	6,3	1,8	411	6,8
62.	10,2	560	-8,0	1,6	373	-9,1
63.	11,5	627	21,6	12,3	707	15,0
64.	9,8	619	13,2	9,1	575	-2,3
65.	11,5	653	4,4	2,2	348	-11,6
66.	10,8	640	7,1	8,8	618	4,7
67.	10,8	624	13,8	10,3	694	-10,8
68.	10,8	616	-27,2	9,2	571	-23,1
69.	11,1	593	23,1	1,7	413	-18,0
70.	11,6	656	2,9	10,9	643	-10,6
71.	11,5	593	-15,0	8,8	517	-33,3
72.	10,8	615	-6,8	9,2	542	-23,4
73.	11,4	711	30,3	12,1	671	13,5
74.	10,5	566	-7,2	1,7	409	-8,2
75.	11,5	592	14,9	12,1	555	14,3
76.	11,4	621	21,1	1,8	393	16,9
77.	14,2	755	17,3	11,3	779	18,2
78.	12,6	640	25,3	10,1	552	-11,0
79.	11,8	646	4,2	12,0	733	5,6
80.	11,5	624	-8,1	11,6	652	12,4
81.	12,3	680	7,1	10,2	620	17,8
82.	11,0	658	21,9	10,7	671	-4,8
83.	13,8	770	-5,9	1,6	405	16,4
84.	10,9	578	32,4	11,0	653	6,0
85.	10,7	646	17,2	11,0	633	7,7
86.	12,3	600	6,8	9,8	558	-9,5
87.	11,5	671	9,9	12,7	674	5,8
88.	11,1	652	4,9	11,5	694	5,0
89.	11,8	613	15,9	11,0	671	-7,4
90.	11,6	607	12,5	11,4	677	31,5
91.	9,3	528	-5,3	1,5	381	-11,3
92.	12,5	590	18,5	10,7	661	-12,1
93.	12,3	632	20,6	12,0	730	6,3
94.	12,5	650	10,6	13,7	705	-7,8
95.	10,2	506	-23,6	8,9	552	-17,8
96.	12,3	609	6,6	10,8	625	-22,8
97.	10,5	487	15,4	9,7	514	1,4
98.	10,0	611	39,0	10,1	583	22,6
99.	9,8	542	7,0	8,7	495	11,9
100.	11,8	588	5,9	11,6	573	4,9
101.	11,7	672	-3,1	11,0	636	3,6
102.	10,5	576	7,2	12,6	574	-10,4
103.	13,7	719	-16,8	11,0	672	6,5
104.	11,2	615	32,3	9,2	564	-4,1

Table 2: Total Database from each athlete for T1 and T2

This general and preliminary assessment was intended to summarize the results of the observations made on the samples of the entire research-population in such a way as to be able to represent the trend of the entire sample with a single value. After carrying out the arithmetic mean, more specific analyses were performed regarding:

- the percentage variation (Δ%): it expresses the difference between the final value (xf) and the initial value (xi) of a quantity in percentage terms, considering the initial value as a reference value. The formula to arrive at its calculation is, as usual the following: $\Delta\% = \frac{x_f - x_i}{x_i} * 100$

  The final and initial values were attributed respectively to T1 and T2, precisely to search for the presence or absence of positive or negative differences between the variables under examination. In fact, according to the sign of the percentage variation, we speak of: percentage increase if the variation is positive, that is, if xf> xi; percentage decrease if the change is negative, i.e. if xf <xi and a zero change if the change is equal to zero, i.e. if xf = xi.

- The other specific analysis performed was about standard deviation (SD) or mean square deviation or square root of the variance.

These statistical indices are essential to clearly test whether the average is reliable or not, therefore it serves to give a meaningful representation of the data. The more it (DS) is close to zero, the more reliable the average is. Finally, its application in this study was carried out on all the means of the parameters under examination in both survey periods, to compare the distribution of the population data with respect to the mean and time.

Results

From the first considerations made about percentage variations of each variable for each player (Tab. 3) it's possible to state that: for the Training Load 74 players (71,16%) had a decrease, 28 an increase (26,92%), and 2 a zero change (1,92%); for the Average strength 52 players (50%) had a decrease, 49 an increase (47,12%) and 3 a zero change (2,88%) and that for the Imbalance 46 players (44,23%) worsened and 58 increased (55,77%). To make the results obtained clearer and more legible, a second analysis step was carried out: the percentage variations of the sums of the averages for each variable for each player in the two measurement periods were calculated.

Ath	Δ % T.L [G]	Δ% Avg.Strenght (N)	Δ IMB %	Ath	Δ % T.L [G]	Δ% Avg.Strenght (N)	Δ IMB %
1.	-4%	17%	-48%	51.	-17%	12%	65%
2.	-44%	-25%	65%	52.	-83%	-38%	22%
3.	-17%	16%	13%	53.	-9%	-2%	-56%
4.	-9%	-18%	-201%	54.	-32%	-11%	60%
5.	-14%	5%	-75%	55.	-87%	-39%	9%
6.	-87%	-33%	-57%	56.	-5%	15%	-715%
7.	3%	9%	51%	57.	-16%	-12%	74%
8.	-85%	-34%	-103%	58.	2%	-5%	-144%
9.	6%	2%	-44%	59.	11%	-10%	-42%
10.	17%	-1%	26%	60.	16%	-14%	45%
11.	-83%	-39%	52%	61.	-85%	-42%	-8%
12.	-2%	22%	80%	62.	-85%	-34%	-13%
13.	12%	42%	-150%	63.	6%	13%	31%
14.	-6%	11%	-3%	64.	-7%	-7%	82%
15.	-7%	-3%	-82%	65.	-81%	-47%	-163%
16.	-86%	-47%	-69%	66.	-19%	-3%	34%
17.	5%	18%	39%	67.	-4%	11%	22%
18.	-21%	7%	35%	68.	-14%	-7%	15%
19.	-4%	2%	-38%	69.	-84%	-30%	22%
20.	-19%	0%	83%	70.	-6%	-2%	-273%
21.	-16%	12%	74%	71.	-23%	-13%	-123%
22.	-9%	3%	33%	72.	-15%	-12%	-246%
23.	-8%	-3%	64%	73.	7%	-6%	55%
24.	14%	18%	-166%	74.	-84%	-28%	-14%
25.	-13%	-5%	49%	75.	5%	-6%	4%
26.	-10%	3%	66%	76.	-85%	-37%	20%
27.	-5%	25%	-115%	77.	-20%	3%	-6%
28.	11%	8%	20%	78.	-20%	-14%	57%
29.	11%	13%	45%	79.	2%	13%	-35%
30.	21%	7%	-216%	80.	0%	4%	-53%
31.	-13%	8%	21%	81.	-17%	-9%	-150%
32.	8%	7%	-17%	82.	-3%	2%	78%
33.	-15%	-5%	-130%	83.	-88%	-47%	-178%
34.	-84%	-35%	-160%	84.	0%	13%	81%
35.	-7%	15%	70%	85.	2%	-2%	55%
36.	-13%	-15%	2%	86.	-20%	-7%	-41%
37.	7%	25%	33%	87.	11%	0%	41%
38.	12%	20%	-60%	88.	3%	6%	-4%
39.	-84%	-34%	-33%	89.	-7%	9%	53%
40.	-2%	13%	2%	90.	-2%	12%	-152%
41.	-85%	-32%	75%	91.	-84%	-28%	-111%
42.	-88%	-37%	45%	92.	-14%	12%	35%
43.	-21%	-11%	83%	93.	-3%	15%	70%
44.	5%	8%	22%	94.	9%	8%	27%
45.	-12%	2%	-49%	95.	-13%	9%	24%
46.	-19%	-4%	79%	96.	-12%	3%	-247%
47.	8%	8%	-25%	97.	-7%	6%	91%
48.	-10%	23%	-797%	98.	1%	-5%	42%
49.	-2%	3%	48%	99.	-11%	-9%	-69%
50.	1%	5%	19%	100.	-2%	-2%	17%
				101.	-6%	-5%	-16%
				102.	19%	0%	-43%
				103.	-20%	-6%	61%
				104.	-17%	-8%	87%

Table 3: percentage variations of each parameter for each player, decreases in red, increases in green, zero changes in white.

From table 4 it's clear that: for the Training Load parameters and for the Average Strength there was a decrease between T1 and T2 of 19% and 4% respectively and instead for the Imbalance measurement there was an increase between T1 and T2 equal to 14%. Furthermore, again for the latter variable, it emerged that: 35 subjects (33.65%) in T1 and 45 (43.27%) in T2 performed the test with a prevalence of left laterality.

	Average		
	T.L [G]	**Avg.Strenght (N)**	**IMB %**
First Test	11,61 ± 1,1	623 ± 61,1	13,8 ± 8,3
Second Test	9,35 ± 3,6	598 ± 115,2	11,9 ± 7,4
Δ %	-19%	-4%	14%

Table 4: Average Data from all athletes from T1 and T2

After having highlighted any quantitative improvements or worsening of the 3 investigated variables, with particular emphasis on Imbalance, we found it interesting to calculate the standard deviation (SD) for each variable in the two tests cycles. Comparing and analysing the results of the SD obtained during the measurement intervals, it's conceivable to argue that: the set of values that deviates most from the arithmetic mean of the values themselves is that of the Average Strength in the T2 (± 115.22 [N]); the distribution of the most regular data series is that of the Training Load in T1 (± 1.15 [G]) and the only improvement observed between the initial distributions (T1: ± 8.35 [%]) and final (T2: ± 7.46 [%]) of values, with respect to the average and over time, is that of Imbalance.

Discussion

First of all, it must be pointed out that the study carried out verified positively that the inertial sensors analyse in a reliable and meaningful way with respect to the topics analysed multi-directional sprint movements such as changes of direction (CoD), even with unusual angles for the existing literature of 90 and 135 degrees, such as those proposed by the test (Lanovaz et al., 2017) The main purpose of this research work was to analyse the three key performance indices during CoD changes of direction in young footballers aged between 11 and 12, ages in which these elements, certainly complex and decisive in performance, however, they are extremely trainable as they are at a favourable time for the progress of coordination and conditional skills (Meinel et al.,1987). The analysis of the results obtained was divided into different phases. In the first phase, the positive or negative variation between the two measurement periods of the performance indicators was evaluated to indicate, albeit at a considerable distance, a first evaluation of the possible improvement curve given by the training work (in a future work we will insert a further if not two further evaluation moments for a more continuous monitoring of the work progress). It can be said that, by relating the initial data with the final ones, it's clear that the only positive difference, indicated by the percentage change, was that of the Imbalance. In fact, taking into consideration the percentage variation of the individual young players, it was shown that 55.77% (n = 58) of the 104 members of the research sample improved their body imbalance; for greater understanding, we will say that, over the course of the season, the entire study population had a percentage increase of 14%, thus improving its symmetry index during the various changes of direction. Another significant parameter, negative in this case, was that of the Training Load; in fact, 71.16% (n = 74) of the population had a worsening with a percentage decrease, on the entire sum of the averages of each subject, equal to 19%. Therefore the quantity of the load developed in the various multidirectional accelerations had a worsening between the two measurement periods. Finally, for the last performance index, Average Strength, a significant difference cannot be highlighted as the percentage decrease was only 4%, making the worsening of the average intensity distribution over time of the test hardly noticeable. This first phase of analysis is shown in the table below (Table 5).

	Δ % First/Second Test	**Average Δ %**
T.L [G]	< 71,16%	< 19%
Avg.Strenght (N)	< 50%	< 4%
IMB %	> 55,77%	> 14%

Table 5: Percentage variation Data

The significant decrease in the amount of training load could be related to the factors and characteristics of the conditional skills involved in the changes of direction. We would speak of "reactive force" and "speed". The first, due to nervous and mechanical peculiarities with respect to rapid force, is considered a form of manifestation of force dependent on factors: morphological-physiological, coordinative and motivational (Neubert 1999). It is understood as the muscular performance that, within a lengthening-shortening cycle, generates a higher impulse of strength (Martin et al., 1991). The factors to be highlighted, therefore, are the morphological-physiological ones which include the anthropometric assumptions (body mass, stature, foot length), muscle mass, muscle "stiffness" and the composition of muscle fibres and coordination ones such as intra and intermuscular coordination (Weineck, 2009) and that, precisely in the pubertal period immediately following the one taken into consideration, due to the thrust of weight and organic growth, they influence this neuro-muscular quality in an even more significant way, significantly depending on the personal genetic heritage. The "speed" on the other hand represents an extraordinarily varied and complex set of abilities, which manifests itself in completely different ways in the various sports.

The specificity of the sports movement in question allows it to be identified in "rapidity of frequency", that is, the ability to perform cyclic movements with maximum speed against low resistance (Schiffer, 1993). This depends on various parameters such as: motor learning, body development, psychic-sensory-cognitive and muscle-tendon abilities (Weineck, 2004). In fact, the physical and physiological changes characterizing pubertal development interact with the psychic ones, thus jeopardizing the ability to "speed" which is significantly important for the motor ability of the change of direction. As regards also the increase in body imbalance (Imbalance), reference could be made to motor learning. As we all know, balancing movements are the result of biomechanical and physiological but also psychological adaptations, that is, consequent to the interpretation of proprioceptive and exteroceptive sensations. In fact, psychic adaptations strictly depend on the quantity and quality of motor experiences, which, facilitating the interpretation of a whole series of proprioceptive and exteroceptive afferent information, allow to improve the motor program of the movement already performed (Cottini, 2003). Therefore, specifically, the components of the research sample both thanks to the training sessions performed during the 7 months and the familiarization period of the test could have expanded their "empirical motor baggage" by improving movements and consequently the dynamic balance. The second phase was carried out with the aim of determining which part of the body was most exploited by the subjects during the 6 changes of direction duly carried out during the test. The results showed a propensity towards right lateral; in fact, in T1 only 33.65% (n = 35) of the subjects had an aptitude for performing the various multi-directional sprints by placing their body centre of gravity to the left; while at T2 only 43.27% (n = 45) (Table 6). Another important note is that derived from the variability of the "Lateral Imbalance" since, in the second measurement period, the analysis showed that 44 young players (about 43.30%) performed the test with an opposite side to the to the one measured previously.

	Left Balance	Right Balance
First Test	33,65% (n=35)	66,35% (n=69)
Second Test	43,27% (n=45)	56,73% (n=59)

Table 6: Differences between left and right balance from T1 and T2

It was highlighted that the performance index that showed a significance of the relevant data was that of the Training Load with a DS equal to 1.15 and 3.67 for T1 and T2 respectively. While it emerged that the only parameter that has had a positive transformation in terms of data in the population samples overtime was the Imbalance with an SD equal to 8.35 in T1 and 7.36 in T2. The conduct of the study highlighted the following limitations: sample not pre-selected and, consequently, not distinguished in relation to those who practice physical activity in school and not; only quantitative data that cover the nuances of human variability and unite the subjects in macro-categories; absence of anthropometric data of the subjects, which may be essential for the recognition of any clarifications on the final results and poor knowledge of the technical background and motor activities in general of the sample. These limits, together with the absence of control and study groups, highlight the descriptive nature of the survey.

Conclusions

To "build" good athletes, attention should be paid to the early, complete and harmonious development of motor skills and, above all, to the analysis of specific-relative motor skills of each phase of human growth. Therefore, in the case of youth football, it would be favourable to analyse in the best possible way those motor variables that are essential for the execution of different movements related to achieving optimal performance. Starting from the considerations that emerged following the results of this research work, focused on the application of inertial sensors for monitoring the performance variables of direction changes, and therefore to give real values that can be interpreted in the various dosages of the proposed exercises. It therefore seems appropriate to emphasize that performance indicators and body symmetry are of fundamental importance for the analysis and implementation of specific performance and the related optimization of training programs. In fact, the Training Load, the Average Strength and the Imbalance respectively expression of force, force distribution and body imbalance provide data on the real capabilities useful for optimal performance of direction changes and, therefore, provide the possibility of creating programs training suitable for the concept of symmetry of the body, which in our opinion would significantly change the performance in all the gestures learned, and also in other sports where ambidextrousism is evidently functional, such as in basketball.

Finally, in addition to underlining that the contribution of the IMUs, due to their extreme precision, was fundamental, in anticipation of future studies related to the subject matter, it could be crucial to be able to define a model for evaluating human movement and, in this case, gestures sports, even more, detailed and optimal from a qualitative point of view thanks to the acquisition of a greater number of optimal specific anthropometric and biomechanical data. Moreover, on the contrary with respect to the release on the market of these instruments, which now dates back to many years ago, a careful use of the study of qualitative improvement elements is not evident in the literature. To conclude a note that seems important to us. We have deliberately not taken into account the preferences of individuals in terms of right-handedness or left-handedness, biologically and psychologically defined, which in terms of the weights of the exercises to be proposed for the equilibrium of the emilates, would have been incisive and misleading compared to our study which at this stage, as previously mentioned, it's meant to be simply descriptive and pedagogical-didactic, and test in the field of some miniaturized technologies, but it will certainly be part of the second analysis step also to define starting situations and related possible improvements over time to be discussed. The final study project will therefore seek, once the starting point and the preferences of the individuals as to preference of one limb over the other or of an eye over the other, what is the dedicated work plan, specific for each of the our athletes, who even more in this case will need work differences we imagine considerable. We like to think that the contribution of a methodology of symmetrical proposition of field work (Izzo R.,1982) would certainly lead, in the near future, to significant and important advantages in the field.

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