Proceeding

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Correlation between running impacts and VO_{2max} in young football players through GPS technology

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ABSTRACT

This study focuses on the "running" component in football, putting attention to the biomechanical and coordinative aspects rather than to the conditional abilities alone. Poor running technique can be linked to heavy impacts. The objective is to find a correlation between the number of impacts and the VO_2max value. Ten young footballers, aged between 13-14 y.o., performed the Gacon test. During the test the number of impacts between 3-5g was recorded with a GPS tracking unit. A correlation was computed between the distance covered and the number of impacts per stage. Another correlation was calculated between the average number of impacts and the number of stages performed. No significant correlation was found between the meters travelled and the number of impacts recorded. On the contrary, a positive correlation (+0.8) was found between the average number of impacts and the total stages performed in the test. Findings suggest the number of impacts does not seem to be indicative of fatigue, while it seems that athletes with a higher $V0_2$max (more stages performed) have more impacts than athletes with lower VO_2max. It can also be considered that the impacts between 3-5g, not detrimental to the body, are an indicator for good use of the muscular elastic component during the running. **Keywords**: Running; GPS; Football; Gacon; Impacts.

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INTRODUCTION

Football is a situational sport, the player always faces variables in a constantly changing environment, whose correct interpretation, with its solution, determines the success of the play.

Examining the physiological demands of football performance, it was found that players, during a game, run on average between 8 and 13 km. This distance has been travelled with intermittent running. The acyclic changes observed in the activity of the players are unpredictable and include changes in intensity, direction and movement. The race is therefore one of the main aspects of the performance. With modern technology it is possible to define exactly the different travel quantities for each player during the whole game. The distance travelled is different and depending on the category of the player, on his individual abilities, on his role.

During running, the typical trend of vertical force is bell-shaped with a possible peak in the initial phase of contact. This peak, called impact peak, represents a passive force, which is due to the shock of contact of the foot with the ground, and it is present, when the subject lands with the heel and it is absent when he lands on the forefoot. In fact, in the support phase, in which the heel is in contact with the ground, a force equal to three or four times the body weight is discharged onto the foot. In a single step a 70 kg runner must withstand a shock of at least 210 kg. The vibrations are reflected upward, affecting the muscles, tendons and bones of the entire leg, pelvis and spine. Therefore, an excellent running technique becomes fundamental in order to cushion the impact with the soil and prevent serious traumas to tendons, ligaments and joints. In the "toe-off" phase of the foot the athlete's weight is transferred from the medial area to the forefoot, triggering a force, which can reach an intensity between 4 and 7 times the body weight. A 70 kg individual, during sustained running, arrives to unleash a shock of 490 kg at each step. (Legnani et al., 2018).

An excellent running technique becomes fundamental in order to cushion the impact with the ground and prevent serious traumas to tendons, ligaments and joints. An individual style is considered acceptable and correct only if it does not affect the correct execution. An athlete, who generates a large amount of energy during landing at every step, cannot claim that it is his personal style, but should rather admit that his running technique is not good. Therefore, a coach must have the competence to be able to understand the relationship between an athlete's technical ability and his personal style. In other words, it is important to make a distinction between those patterns of movement which can be referred to as personal style (and therefore should not be corrected) and those that must be labelled as defective (i.e. they are contrary to morphology and function). These must be corrected through a specific workout. (Bosh F., Klomp R., 2004).

In this study the focus was putted on the biomechanics and the coordination of technical gestures rather than to conditional abilities.

The aim of this research is to find a correlation between the number of impacts of athletes and their value of VO_2max. Thus, a possible correlation between conditional factors and coordinating factors was studied. In particular, the conditional factors were examined with the Gacon test and the coordinating factors were analysed by a GPS unit with an integrated accelerometer, counting the number of impacts between 3g and 5g. The hypothesis states that: as the performed stages progress and the effort of the individual increases resulting in more fatigue, the number of impacts increases as well between 3g and 5g. It is important to remember that, for an athlete, a good running technique, in addition to reducing the chances of injury, can reduce the energy cost of the performance.

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MATERIAL AND METHODS

The sample examined consists of ten subjects (age 13.9 ±0.5 years, height 163.7 ±8.6 cm, weight 57.8 ±8.2 kg). They attend a soccer school in Nocera Inferiore (Salerno, Italy) regularly (four training sessions a week). Athletes performed the Gacon Test. It is a maximal progressive test. Players started from the set point (fixed point) and within 45 seconds must travel 125 meters; in the recovery of 15 seconds they had to go to the next starting point, which was 6.25 meters from the point of arrival. After recovery, they returned to the initial starting point, called the fixed point, traveling 131.5 meters in 45 seconds, and so on, for the following stages. The test preserves the classic increase of 0.5 km / h per minute, the initial speed is 10 km / h in progression, increasing the path by 6.25 m, it also increases by 0.5 km / h the speed of running. The test ends, when the athlete is no longer able to travel the set course in 45 seconds. The test can estimate the value of VO_{2max} by multiplying the fraction speed by three. A value of VO_{2max} is associated to each stage as shown in table 1.

Table 1. Average speed, distance and VO_{2max} values per stage of the Gacon test.

STAGE	AVG. SPEED (KM/H)	TOTAL DISTANCE (M)	VO_{2MAX} (ML/KG/M)
1	10	125	30
2	10.5	131.5	32
3	11	138	33
4	11.5	144.5	35
5	12	151	36
6	12.5	157.5	38
7	13	164	39
8	13.5	170.5	41
9	14	177	42
10	14.5	183.5	44
11	15	190	45
12	15.5	196.5	47
13	16	203	48
14	16.5	209.5	50
15	17	216	51
16	17.5	222.5	53
17	18	229	54
18	18.5	235.5	56
19	19	242	57
20	19.5	248.5	59
21	20	255	60
22	20.5	261.5	62
23	21	268	63
24	21.5	274.5	65
25	22	281	66
26	22.5	287.5	68
27	23	294	69
28	23.5	300.5	71
29	24	307	72
30	24.5	313.5	74
31	25	320	75

Following the indications, to perform the Gacon test, along the lines of the soccer field, present in Nocera Inferiore (length 100m and width 50m), cups were placed, in alternate colours, at 6.25 m from one to the next. The participants, after a fifteen minutes brief warm-up, were divided into two groups of five. Participants were equipped with a GPS unit (Playertek) with an integrated triaxial accelerometer (400hz) and were personally followed by an instructor during the execution of the test.

Each test was processed individually. Through the PLAYERTEK on-line platform the totality of the test was divided into several stages. Following the stages of the Gacon test, through the PLAYERTEK online platform, the totality of the test was divided into one-minute stages. Each participant, obtained a different result at the Gacon test, also totalized a different number of stages. Table 2 shows the results of the Gacon test for each athlete. Table 3 lists the data, for each individual athlete, of the total number of impacts between 3g and 5g and between 5g and 10g.

Table 2. Gacon test results for each athlete.

ATHLETE	N° OF STAGE	LAST STAGE DISTANCE (m)	MAX SPEED (km/h)	VO_{2max} (ml/kg/min)	TOTAL DISTANCE (m)
Athlete 1	17	229	18	54	3009
Athlete 2	17	229	18	54	3009
Athlete 3	15	216	17	51	2557.5
Athlete 4	15	216	17	51	2557.5
Athlete 5	13	203	16	48	2132
Athlete 6	13	203	16	48	2132
Athlete 7	11	190	15	45	1732.5
Athlete 8	11	190	15	45	1732.5
Athlete 9	10	183.5	14.5	42	1542.5
Athlete 10	10	183.5	14.5	42	1542.5

Table 3. N° of impacts for each athlete.

ATHLETE	STAGE	IMPACTS 3G- 5G	IMPACTS 5G-10G
Athlete 1	17	650	0
Athlete 2	17	795	0
Athlete 3	15	351	0
Athlete 4	15	525	1
Athlete 5	13	145	0
Athlete 6	13	117	2
Athlete 7	11	147	1
Athlete 8	11	102	0
Athlete 9	10	66	1
Athlete 10	10	220	1

A correlation was computed between the distance covered and the number of impacts per stage (table 4). To perform the second correlation, it was useful to normalize the data. As all the Gacon test participants arrived at least up to stage number 10, we will average all the impacts up to the tenth stage (table 5). Another correlation was calculated between the average number of impacts and the number of stages performed.

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Table 4. Correlation between distance and n° of impacts for each athlete.

ATHLETE	CORRELATION BETWEEN DISTANCE COVERED AND N° OF IMPACT/STAGE
Athlete 1	0.46
Athlete 2	0.31
Athlete 3	0.06
Athlete 4	0.15
Athlete 5	0.72
Athlete 6	-0.04
Athlete 7	0.70
Athlete 8	0.73
Athlete 9	0.25
Athlete 10	-0.24

Table 5. Average n° of impacts up to stage 10 and n° of total stages performed by each athlete.

ATHLETE	AVERAGE N° OF IMPACTS UP TO STAGE 10	N° OF STAGE
Athlete 1	29.8	17
Athlete 2	41.4	17
Athlete 3	22	15
Athlete 4	29.3	15
Athlete 5	8.9	13
Athlete 6	6.4	13
Athlete 7	10.8	11
Athlete 8	8.1	11
Athlete 9	6.4	10
Athlete 10	19.9	10

RESULTS

No significant correlation was found between the meters travelled and the number of impacts recorded. On the contrary, a positive correlation (+0.8) was found between the average number of impacts and the total stages performed in the test.

DISCUSSION

The Gacon test is a maximal progressive test: at each stage, with a fixed duration of 45 seconds and 15 seconds of recovery, the athletes increase the distance travelled by 6.25 meters, thus increasing by 0.5 km / h the running speed. The test ends, when the athlete is no longer able to walk the set course in 45 seconds. It is announced that the athlete 10 plays the role of goalkeeper. The hypothesis states that: as the performed stages progress and the effort of the individual increases resulting in more fatigue, the number of impacts increases as well between 3g and 5g. As shown in Table 4, it is clear that it is not possible to state that there is a correlation between the meters travelled and the impacts for each distance, therefore, it is not possible to state that the impacts between 3g and 5g increase as the distance travelled increases. In other words, the impacts are not an evidence of fatigue in the athlete's body.

Now consider the role of impacts between 3g and 5g in the athlete's run.

The triaxial accelerometer contained in the GPS quantified the number of overall impacts on the athlete's body. We can affirm that impacts less than 5-6 g are very light (C. P. Mclellan et al. 2011; C. Cummins et al. 2013), caused by a sudden acceleration and deceleration or a change of direction during running and do not involve damages for the athlete's body (table 6).

Table 6. Impact zones divided by G-force range.

ZONE	DESCRIPTION	G-FORCES
Zone 1	Light	>5-6
Zone 2	Moderate	6-6.5
Zone 3	Moderate-Heavy	6.5-7
Zone 4	Heavy	7-8
Zone 5	Very Heavy	8-10
Zone 6	Severe	10>

Findings show that athletes with a higher VO_{2max}, during running, have more impacts than athletes with a lower VO_{2max}. In fact, as shown in Table 5, there is a positive correlation (+0.8) between the final stage reached and the number of impacts. Athletes who complete more stages have more impacts between 3g and 5g compared to athletes who complete less stages.

According with what was stated by F. Bosh (Bosh, 2018), training creates a series of muscular adaptations, which allow to absorb and restore peak forces during running. This allows to hypothesize that an athlete, who travels a greater distance, uses impacts between 3g and 5g in his favour.

Running differs from walking in some aspects. In particular, the kinetic and potential (gravitational) energy during running change in phase, unlike what happens during walking, where they are opposite. In fact, the gravitational potential energy of the body (PEgrav), as well as the vertical and horizontal kinetic energy (KEv and KEh respectively), decrease simultaneously from the initial contact on the ground up to the central support phase, while they increase simultaneously during the propulsive phase up to the pre-swing phase. In theory, this prevents the exchange between potential and kinetic energy, which occurs in the path, increasing the energy cost of locomotion. As the muscle-tendon units store and release elastic energy when the leg compresses and extends during the support phase, the leg, acting as an elastic spring, reduces the loss of energy during contact with the foot on the ground. This improves the efficiency of movement, storing PEgrav (and part of KEv and KEh), and facilitating propulsion in the next stage where both KE and PEgrav return to growth. It is estimated that re-use of elastic energy provides more than half of the energy needed for propulsion during running (Blazevich, 2017).

We can assume that the impacts between 3g and 5g, being events that are not harmful to the body, may indicate a good use of the muscular elastic component during the race.

CONCLUSIONS

Findings suggest that the number of impacts does not seem to be indicative of fatigue, while it seems that athletes with a higher V02max (more stages performed) have more impacts than athletes with lower VO_{2max}. We can also consider that the impacts between 3-5g, not detrimental to the body, are an indicator for good use of the muscular elastic component during running.

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