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The effects of a soccer season on anthropometric characteristics, physical fitness, and soccer skills in North African elite female youth soccer players

Les effets d'une saison de football sur les caractéristiques anthropométriques, la performance physique et les habilités en football chez des jeunes joueuses élites nord-africaines

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Running title: Fitness parameters in women soccer players.

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1 **Abstract**

2 **Background and objectives:** In comparison to their European counterparts, there are scarce data
3 regarding skill performance in young elite female North African soccer players. The objectives
4 of this study were to evaluate the effects of a season-long training regime on anthropometric
5 and physical performance characteristics, agility, and soccer skills in Tunisian youth elite fe-
6 male players.

7 **Materials and Methods:** Forty-eight females (24 soccer players SG; 24 non-playing controls,
8 CG) were evaluated at the start of a preparatory period (T1) in September, and 10 months later
9 in June (T2), the end period of the competitive season. Anthropometrics (body mass, body
10 composition), soccer-specific cardiorespiratory endurance (Yo-Yo Intermittent Recovery Test
11 Level 1; YYIRT1), muscle power (countermovement jump [CMJ]; squat-jump [SJ]; 5-Jump-
12 Test [5JT]), agility (T-test with and without ball), soccer skill (Loughborough Soccer Passing
13 Test, LSPT) and sprint speed (30 m sprint with 5 and 10 m splits) were measured.

14 **Results:** The SG experienced significant performance improvements in all tests across the pe-
15 riod of the competitive season, demonstrating better improvements in height ($p < 0.0001$, ES=
16 1.69), weight ($p < 0.0001$, ES= 0.92) and BF ($p < 0.0001$, ES= 1.63). Better CMJ ($p < 0.0001$, ES=
17 1.63), SJ ($p < 0.0001$, ES= 1.33), and 5JT performances than the CG ($p < 0.004$, ES= 0.39). Sim-
18 ilarly, the SG performed better in the sprint, agility, and LSPT tests and covered longer dis-
19 tances in YYIRT1 ($p < 0.0001$) compared to the CG.

20 **Conclusion:** Soccer season training contributed to significant variations in anthropometric
21 characteristics, physical fitness, and soccer skills in Tunisian elite female youth soccer players
22 compared to control group that are beyond those which could be expected through biological
23 maturation alone.

24 **Key words:** performance indicators, development, annual training, adolescent elites

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1 **Résumé**

2 **Contexte et objectifs :** par rapport à leurs homologues européens, il existe peu de données
3 concernant les performances des jeunes footballeuses élites nord-africaines. Les objectifs de
4 cette étude étaient d'évaluer les effets d'une saison d'entraînement de football sur les caracté-
5 ristiques anthropométriques, la performance physique, l'agilité ainsi que certaines habilités
6 footballistiques chez les jeunes joueuses élites tunisiennes.

7 **Matériels et méthodes :** Quarante-huit filles (24 footballeuses GF ; 24 témoins non-joueuses,
8 GC) ont été évaluées au début d'une période préparatoire (T1) en septembre, et 10 mois plus
9 tard en juin (T2), la période de fin de la saison compétitive. Anthropométrie (masse et compo-
10 sition corporelles), endurance cardiorespiratoire spécifique au football (Yo-Yo Intermittent Re-
11 covery Test Level 1 ; YYIRT1), puissance musculaire (contre-mouvement jump [CMJ] ; squat-
12 jump [SJ] ; 5-Jump-Test [5JT]), l'agilité (T-test avec et sans ballon), l'habileté au football
13 (Loughborough Soccer Passing Test, LSPT) et la performance en sprint (sprint de 30 m avec
14 des intervalles de 5 et 10 m) ont été mesurés.

15 **Résultats :** Le GF a présenté des améliorations significatives des performances dans tous les
16 tests tout au long de la période de la saison de compétition, démontrant de meilleures améliorations
17 en taille ($p < 0,0001$, ES= 1,69), masse corporelle ($p < 0,0001$, ES= 0,92) et BF ($p < 0,0001$,
18 ES= 1,63), de meilleures performances en CMJ ($p < 0,0001$, ES= 1,63), SJ ($p < 0,0001$, ES= 1,33)
19 et en 5JT que le CG ($p < 0,004$, ES= 0,39). De même, le FG a obtenu de meilleurs résultats dans
20 les tests de sprint, d'agilité et de LSPT et a couvert une plus longue distance en YYIRT1 (p
21 $< 0,0001$) par rapport à CG.

22 **Conclusion :** L'entraînement au cours d'une saison de football a contribué à des variations si-
23 gnificatives des caractéristiques anthropométriques, de la condition physique et des habilités
24 footballistiques chez des jeunes joueuses de football élites tunisiennes par rapport au groupe
25 témoin. Ces améliorations ne semblent pas pouvoir être expliquées uniquement par la seule
26 maturation biologique.

27 **Mots clés :** indicateurs de performance, développement, saison d'entraînement, élites adoles-
28 centes.

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1 **1. Introduction**

2 Women's soccer is inexorably rising in popularity with the number of female players worldwide
3 being estimated to be around 30 million [1, 2]. That number has increased in recent years by
4 approximately 50%, considering the most recent report of FIFA [3]. In view of this increase,
5 several researchers have sought to understand the characteristics of these players, their physio-
6 logical and physical requirements, and their training processes [1,4,5]. Recently, Gonçalves, et
7 al. [6] analyzed the relationships between fitness status and match running performance and
8 explored the main determinants of repeated-sprint ability in women soccer players considering
9 aerobic capacity, sprinting performance, change-of-direction, vertical height jump, and hip ad-
10 ductor/abductor isometric strength [6]. Moreover, a new investigation has examined the anthro-
11 pometric profiles and evaluated physical fitness variables of a women's national football team
12 based on their playing positions [7]. However, despite this growing trend, compared to other
13 continents, the number of licensed players is still small in Africa, especially in North Africa,
14 where the women's game is less developed. Traditionally, male African players have been both
15 prominent and successful in the major soccer leagues of Europe. However, females from the
16 continent are less well-represented in their equivalent leagues, whilst the number of females
17 who play the sport is comparatively smaller [8, 9].

18 Soccer is a multi-faceted sport in which the most talented players possess excellent technical
19 and tactical acumen, high physical fitness, and specific anthropometric characteristics [10]. Ac-
20 cordingly, coaches at the elite level are persistently searching for the most successful methods
21 to identify and develop talented young soccer players [11]. In the field of scientific research in
22 soccer, a number of studies have elucidated the physical characteristics of female players in
23 Europe and the United States [1, 12-16]. However, mainly because of the low number of Afri-
24 can female players, studies in this population are scarce, thus necessitating further investigation

1 of the salient issues in the women's game. Since females differ from males in many physical
2 parameters related to soccer [14], an objective evaluation of young female players' potential,
3 in addition to a description of anthropometric, technical, and tactical abilities, would be of in-
4 terest to coaches and scientists engaged in the development of female talent at the foundational
5 level of soccer in Africa [12, 13]. Many scientific papers have indicated that the physiological
6 load reported during matches are similar across gender suggesting that the aerobic system is
7 heavily burdened throughout and particularly during intense periods of a game [13]. However,
8 female players appear to possess a lower physical capacity than male players across a range of
9 aerobic and anaerobic fitness tests [17, 18]. Thus, it is not surprising that studies have reported
10 that high intensity running in elite female matches is 30% lower than their male counterparts of
11 a similar competitive standard [14, 19]. Two reviews focusing on the physical and physiological
12 demands of women's soccer have been published [20] but, up to now, studies have only exam-
13 ined the effect of seasonal training on anthropometric characteristics and physical and technical
14 qualities in adults [21-24] and young male players [25-27]. To our knowledge, no data on North
15 African female soccer players has yet been published even though the game is historically well
16 established on the continent. Moreover, there is no data pertaining to skill performance in U17
17 female African players. These observations demonstrate the need to put more emphasis on fe-
18 male youth players with a view to developing the scientific approach to women's soccer in
19 African populations. The purposes of this study were, therefore, to investigate skill perfor-
20 mances and to evaluate the effect of a season-long training regime on anthropometric and phys-
21 ical performance characteristics, agility, and soccer skills, compared to age-matched controls,
22 in young female North African elite soccer players.

23 **2. Methods**

24 **2.1. Participants**

1 Forty-eight females volunteered to participate in our study. This group of elite players was se-
2 lected from six regional centers of football throughout Tunisia. The first selection from these
3 centers was conducted among 180 young female soccer players. The criteria used for selection
4 was based on technical tests and physical fitness parameters. The other 26 participants (age 14.3
5 + 0.3 years), were assigned to the control group (non-athletic girls). They participated only in
6 the compulsory physical education curriculum at school (two weekly sessions of 50 min), were
7 randomly chosen and were representative of the general population. No dropouts were reported
8 during the experimental period. Prior to the study, written informed consent for participation
9 was obtained from each subject and their parents or guardians, and the study was approved by
10 the Institutional Ethics Committee of High Institute of Sport and Physical Education of Kef,
11 Tunisia (approval number: IEC- HSPE-19062020). Furthermore, the present study was con-
12 ducted according to the Declaration of Helsinki and its latest amendments.

13 **2.2. Experimental procedures**

14 Comparisons between groups were facilitated by using traditional field fitness tests that have
15 previously been reported to be relevant to soccer [14, 28]. All participants were evaluated at
16 two time-points during the season: *i*) at baseline, at the start of a preparatory period (T1) in
17 September; and *ii*) ten months later in June (T2), at the end of the competitive season. The tests
18 were performed by the elite female soccer players and the control group at the same time (be-
19 tween 8:00 and 12:00) and the same place (**Figure 1**). All test procedures were supervised by
20 the same assessors and all participants were familiarized with all test procedures. Testing was
21 conducted over a three-day period (Figure 1). Across the three testing days, all participants
22 performed a standardized 15-min warm-up consisting of low-intensity running, a series of dy-
23 namic stretching exercises (high knee lifts, butt kicks, straight line skipping, etc.) and short
24 accelerations. On the first day, participants performed a SJ, CMJ with arm swing allowed, a

1 5JT and a 30-m sprint. During the second day, participants performed the agility tests and soccer
2 skill test [LSPT]. On the third day, participants performed a Yo-Yo IRT Level 1 (**Figure 1**).
3 All tests were conducted in the same order.

4 **2.3. Anthropometric characteristics**

5 Each participant came to the laboratory for a medical examination and anthropometric meas-
6 urements, which were collected by a paediatrician before and after the soccer season period.
7 Height and body mass were measured with standard techniques to the nearest 0.1 cm and 0.1
8 kg, respectively. To estimate adiposity, skinfold thickness was measured at four sites on the
9 left-side of the body (triceps brachii, biceps brachii, subscapular and suprailiac) using a skinfold
10 calliper (Harpenden, British Indicators Ltd., Luton, UK) for the calculation of body fat percent-
11 age according to the equations presented by Durnin and Webster [29]. All measurements were
12 taken in the morning by the same investigator (T1 and T2).

13 **2.4. Puberty stage assessment**

14 The puberty stage was the indicator of biological maturity status. It was determined and rec-
15 orded by a pediatrician experienced in the assessment of secondary sex characteristics accord-
16 ing to the method of Tanner [30]. Girls at pubertal development stages 1–5 were evaluated. At
17 the beginning of the study, according to their pubescent status, the young female soccer players
18 and the control group belonged to Tanner stage (4-5).

19 **2.5. Physical fitness characteristics**

20 All tests were undertaken by the same investigators and were scheduled at the same time of
21 day, being carried out in the same order and using the same apparatus for each test period. All
22 jumping tests were performed on a concrete surface with the players wearing running shoes.

1 The running speed tests were performed on an artificial soccer pitch with the two groups wear-
2 ing conventional soccer cleats. Each participant was instructed, and verbally encouraged, to
3 exert maximal effort during all tests.

4 **2.5.1. Vertical jumping**

5 Each participant performed two kinds of maximal jump. For the SJ, participants started with
6 knees bent at a 90° angle, and without a preceding counter movement, jumped vertically from
7 a stationary position by extending the legs as forcefully as possible. For CMJ, the participants
8 initiated the movement from a standing position allowing for a counter movement prestretch
9 with the intention of achieving a flexed knee angle of around 90° prior to propulsion. The forces
10 generated during these vertical jumps were estimated with an ergo jump apparatus (Opto Jump
11 Microgate, Italy). In addition, participants performed the 5JT [31]. Each participant performed
12 three trials in total, inter-spersed with a 1-min rest between each jump, with the best jump being
13 used for analysis [31].

14 **2.5.2. Running speed test**

15 The time needed to cover 5 m, 10 m, and 30 m was measured with an infrared photoelectric cell
16 (Cell Kit Speed, Brower, USA). The participants were encouraged to run as fast as they could,
17 performing three trials in total. There was a 3-min recovery period between each trial. The best
18 (fastest) 30-m sprint time and the associated 10 m and 5 m split times were selected for analysis.

19 **2.5.3. Agility (T-test)**

20 The T-test is a measure of multidirectional agility and body control that evaluates an individ-
21 ual's ability to change directions rapidly whilst maintaining balance and speed (Pauole et al.,

1 2000). Performance in the T-test (with and without ball) was measured with infrared photoe-
2 lectric cells (Cell Kit Speed Brower, USA).

3 ***2.5.4. Loughborough Soccer Passing Test (LSPT)***

4 The LSPT was developed to assess the multifaceted aspect of soccer skill execution including
5 passing [32]. Briefly, this test consisted of 16 passes, against coloured target areas, performed
6 within a circuit of cones and grids as quickly and as accurately as possible. Three indices of
7 performance were calculated: the time necessary to complete the 16 passes (LSPT time); accu-
8 mulated penalties, which were calculated from the errors committed by each player during the
9 test execution (LSPT penalty time), and total performance (LSPT total performance). Scoring
10 was based on the time taken to complete the test after adjustment for penalties and bonus time.

11 All participants were familiarized with the LSPT during a one-week period (four times per
12 week) before testing. They performed a total of two trials, with a 5-min recovery period between
13 each trial. The best LSPT total performance time was selected for analysis.

14 ***2.5.6. Yo-Yo Intermittent Recovery Test Level 1***

15 The Yo-Yo IRT Level 1 test was performed according to the procedures described by Krusturp
16 et al [33]. Briefly, the YoYo IRTL1 consists of repeated 20-m runs back and forth between a
17 starting, turning, and finishing line, at a progressively increased speed, controlled by an audio
18 metronome. Participants had a 10-s active rest period (decelerating and walking back to the
19 starting line) between each running bout. Participants stopped of their own volition or were
20 mandatorily withdrawn from the test if they failed to reach the finishing line in time on two
21 occasions. The total distance covered was recorded for analysis.

22 **2.6. Sample size**

1 The total sample size was estimated using the following formula [34]:

$$N = \frac{(r + 1) (Z_{\alpha/2} + Z_{1-\beta})^2 \delta^2}{r d^2}$$

2
3 • “ N ” is equal to $n_1 + n_2$ (“ n_1 ” and “ n_2 ” are the sample sizes for the two groups of soccer
4 player and the control group).

5 • “ $Z_{\alpha/2}$ ”: normal deviate at a level of significance (= 2.58 for 1% level of significance);

6 • “ $Z_{1-\beta}$ ”: normal deviate at $1-\beta\%$ power with $\beta\%$ of type II error (= 1.64 at 95% statistical
7 power);

8 • “ r ” (equal to n_1/n_2): ratio of the sample size required for the two groups ($r = 1$ gives the
9 sample size distribution as 1:1 for the soccer players and the control group).

10 • “ δ ” and “ d ” are the pooled standard-deviation (SD) and the difference of the 30 m test
11 means of the two groups determined at T1. These two values were obtained from a previous
12 study having a similar hypothesis and including 24 male soccer players (mean \pm SD of age and
13 weight were 14.5 \pm 0.4 years and 67.7 \pm 5.6 kg, respectively), and 26 non athletic boys (mean \pm SD
14 of age and weight were 14.3 \pm 0.3 years and 53.6 \pm 6.1 kg, respectively) [25]. During the T1 pe-
15 riod, the soccer players had a 30 ms sprint time of 4.5 \pm 0.2 s and the non athletic boys had a 30
16 m sprint time of 5.2 \pm 0.1 s [25].

17 The total sample size was 48 (24 soccer players and 24 control group). The assumption of 20%
18 of nonattendance during the second testing experimental condition gave a revised sample of 60
19 [= 48/(1-0.20)].

20 **2.7. Statistical analyses**

1 Data are presented as mean \pm SD. Normality and homogeneity of variance for all data were
2 checked with the Shapiro-Wilk and Levene's tests, respectively. For statistical analyses, an
3 analysis of covariance (ANCOVA), with group as a between-subject comparator (SG and CG),
4 and baseline data as a covariate, was computed due to significant baseline differentials across
5 all baseline values between the two groups. Bonferroni post hoc tests were used if main effects
6 or interactions were identified. This method has been proposed as the most sufficient statistical
7 approach for the analysis of continuous outcomes (Vickers and Altman 2001). Effect sizes (ES)
8 were determined from ANCOVA output by converting partial eta-squared to Cohen's "d" (Co-
9 hen, 1988). Within-group ES were computed using the following equation: $ES = (\text{mean post} -$
10 $\text{mean pre})/SD$ (Cohen, 1988). In accordance with Hopkins et al. (2009), ES were considered
11 trivial (<0.2), small (0.2-0.6), moderate (0.6-1.2), large (1.2-2.0) and very large (2.0-4.0) (Hop-
12 kins et al., 2009). The level of significance was set at $p < 0.05$, *a priori*. Additionally, intraclass
13 correlation coefficients (ICC) and coefficients of variation (CV) were computed to assess rela-
14 tive and absolute test-retest reliability (Table 1). All analyses were performed using Statistical
15 Package for Social Sciences (SPSS) version 24.0 (SPSS Inc., Chicago, Illinois, USA).

16 **3. Results**

17 All players from the SG completed the study. There was a 95% adherence rate across all groups
18 and none reported any training or test-related injury. The ICCs for the assessed physical test
19 variables ranged from 0.879 to 0.995, indicating good to excellent agreement between trials,
20 while CVs ranged from 1.24 to 9.73 %, indicating good intra-test reliability (Table 1).

21 During the soccer season, height and weight results showed that there was a main effect of time
22 for the SG in height and weight, respectively ($p < 0.011$; $ES = 0.54$, small; $p < 0.006$; $ES = 0.75$,
23 moderate) (Table 2). Significant performance improvements were found over the soccer season
24 in physical fitness with a large ES being observed in S10 sprint test, T-test with and without

1 ball and YYIRTL1. Large significant differences magnitude were identified for height
2 ($p < 0.0001$; ES = 1.69, large), while %BF was lower in the SG compared to CG which demon-
3 strated a very large ES ($p < 0.0001$; ES = 3.112) (Table 2). In addition, the SG had a higher CMJ
4 ($p < 0.0001$, ES= 1.63, large), SJ ($p < 0.0001$, ES= 1.33, large) and 5JT ($p < 0.004$, ES= 0.39,
5 small) (Table 3) whilst the effect sizes for linear sprint were small. For agility and the LSPT,
6 performance was significantly lower in SG compared to CG (ES= 1.12, moderate) (Table 4).
7 Moreover, compared to the CG, the SG covered greater distances during YYIRTL1 ($p < 0.0001$;
8 ES=1.93, large) (Table 4).

9 **4. Discussion**

10 The main findings of the study showed that anthropometric parameters, physical fitness and
11 soccer skills changed during a one-season training program in young female soccer players. Ac-
12 cordingly, this research provides novel reference data for Tunisian high level female soccer
13 players, aged 16.5 ± 0.4 years. To the authors' knowledge, this is the first study to examine skill
14 performance and evaluate the effect of a season-long training regime on anthropometric and
15 physical performance characteristics, agility, and soccer skills (LSPT) in young North African
16 elite female soccer players, compared to age-matched controls. The two groups were evaluated
17 before and after a 10-month competitive season. Several studies have examined the relationship
18 between measures of training load, anthropometry, body composition, and/or physical fitness in
19 elite adult soccer players over the course of a soccer season [21- 24]. Findings from these stud-
20 ies indicate significant variations in body composition and physical fitness according to the
21 demands of the respective training period. Regarding anthropometric characteristics, our study
22 demonstrated significant seasonal increases between T1 and T2 for the SG in body height and
23 weight, alongside a reduction in body fat (Table 2). Similarly, many studies have demonstrated
24 that anthropometry and body composition changes occur during a soccer training season in both

1 male and female young soccer players [25, 35, 36]. Indeed, Hammami et al. [25] found
2 significant increases in body height in young elite male soccer players (15 ± 0.5 years). Lesinski
3 et al. [35] demonstrated significant increases in body height, body mass, and relative body fat
4 during a training season for female young soccer players. The expected finding could aid in our
5 understanding of the factors contributing to the change of physical characteristics, as well as in
6 further refining the accuracy of early selection, training, and testing procedures in female soc-
7 cer. Concordantly, Lesinski et al. [35] reported a significant main effect of time for almost all
8 anthropometric and body composition measures, except for body mass index, in young female
9 elite soccer players (15.3 ± 0.5 years). In the present study, compared to the CG, the SG showed
10 significant differences in height, weight, and in percentage of body fat (% BF) (Table 2), with
11 the SG being significantly taller and heavier. Correspondently, some studies [37- 39] have
12 shown that sport participation has beneficial effects on growth and, accordingly, reported that
13 young soccer players were taller and more skeletally mature, compared to their chronologically
14 age-matched counterparts [25, 40-43].

15 In the current study, significant increases in fitness were observed in the SG during the 10-
16 month study period. The female players had significantly greater jump height (in CMJ, SJ and
17 5JT) (Table 3), better performance in Yo-YoIR1 and had faster 10 m and 30 m sprint times
18 between T1 and T2 (Table 4). Similarly, the female soccer players had improved performance
19 in agility (T-test with and without ball) and in performance of LSPT (Table 4). Given these
20 results, it appears that the superior performances revealed by the significant differences in fit-
21 ness parameters may be facilitated by higher training volumes and regular soccer competition
22 in the female soccer players.

23 Chamari et al. [31] showed that CMJ, SJ and 5JT are reliable tests for evaluating a player's
24 ability to achieve high muscular power in the lower limbs, which is of great importance in

1 soccer performance. Regarding muscular power, our data agrees with the study of Sander et al.
2 [44] who mentioned that in soccer, strength, power and speed are very important because of the
3 large number of power actions performed during the game. They examined the influence of
4 periodised strength training for power performance during 2 seasons and they found that for
5 strength training, there was significantly better performance from the soccer training group.
6 And in the sprint, significantly better improvements were displayed of up to 6% [44]. Further,
7 our results correspond with the data of Todd et al. [45] who demonstrated significant differences
8 in vertical jump height in English female players and suggested that performance in this test is
9 a discriminating variable in the identification of talented female soccer players. Also, Manson
10 et al. [2] concluded that coaches should emphasize the development of speed, maximal aerobic
11 velocity and leg strength in developing female soccer players; concomitant to Mujika et al. [18]
12 who posit that coaches should consider specific explosive strength training when working with
13 prospective female soccer players.

14 In soccer games, 96 % of sprint bouts are shorter than 30m in distance, with 49% of those being
15 shorter than 10m. Haugen et al. [46] indicated that straight-line sprinting is the most frequent
16 action before goals, both for the act of scoring, and in assisting another player to do so. In this
17 study, female soccer players were faster in 10 m and 30 m sprinting speed after 10 months of
18 soccer training, and these results are similar to those presented by Mara et al. [22] who reported
19 variation in training demands, physical performance and player well-being across a women's
20 soccer season. The aforementioned authors showed that speed in 5 m, 15m, and 25m sprints
21 increased significantly after one season of training. These results can be contextualised by evi-
22 dence put forward by Wong et al. [47] by reference to anthropometric characteristics. These
23 authors demonstrated that stature was significantly correlated with 10 m and 30m sprint speed
24 and that body mass was significantly correlated with the latter of those two tests. Jovanovic et
25 al. [48] showed that agility was an important component of soccer play and mentioned that a

1 training program of agility, with and without a ball, was found to be an effective way of im-
2 proving some aspects of power performance.

3 In the present study, agility was assessed as time taken to complete a T-test with and without
4 the soccer ball with the SG displaying statistically significant increases between T1 and T2.
5 Accordingly, our study shows that one season of soccer training could exert positive effects on
6 agility with and without a ball in female players with these enhancements in performanc poten-
7 tially due to coordination exercises carried out throughout the year. Indeed, such practices were
8 deemed important by Weineck [49] who included relevant technical elements within condition-
9 ing training to improve agility which is considered a key demand in contemporary soccer play
10 [50, 51]. Our results relating to agility performance were in agreement with the study of Zoran
11 et al. [52] who demonstrated that 12 weeks of a conditioning program involving speed, agility,
12 and quickness training was an effective way of improving agility, with and without the ball, in
13 young soccer players and can be included in physical conditioning program.

14 In our study, the young female players demonstrated statistically significant difference in LSPT
15 performance times between T1 and T2 ($p < 0.0001$). The observed results of this test reflect those
16 reported in a study in elite female players by Ali et al. [53] but were lower in magnitude than
17 those reported in young players elsewhere in the literature [54]. This can be explained by the
18 documented differences in performance between boys and girls, with sex-specific training
19 seemingly key for optimal preparation [55].

20 Our results showed a significant increase in the total distance covered during the Yo-Yo test
21 (level-1) with this finding potentially explainable by the training intensity to which these ath-
22 letes were exposed throughout the training period. Our results at T2 are equivalent to those
23 presented by Mujika et al. [18] for junior female soccer players ($826 \text{ m} \pm 160$) and Zoran et al.
24 [52] who showed that Serbian elite female soccer players (aged 23.95 ± 4.52) covered between

1 880m and 930 m. Similarly, Nosomu and Kuzuhara. [56] reported that Japanese first division
2 female players (aged 19.4 ± 0.9 years) performed achieved a mean distance of 889 ± 321 m. The
3 distances covered by the SG in our study were lower than those in the Yo-YoIR1 for profes-
4 sional female first division players from the Danish League (mean 1379 m, range 600–1960 m)
5 during the competitive season [10], and also lower than those of Mujika et al. [18] for senior
6 female first division players ($1224\text{ m}\pm 255$). Research by Castagna et al. [57] and Krstrup et
7 al. [33] indicates that differences in Yo-YoIR1 performance have been reported depending on
8 training status, period of the season, and explosive strength of the lower limbs in soccer players.

9 **5. Strengths and limitations**

10 The present study, to the authors' knowledge, represents the first work to have examined skill
11 performance and evaluated the effect of a season-long training regime on anthropometric and
12 physical performance characteristics, agility, and soccer skills (LSPT) in young North African
13 elite female soccer players, compared to aged-matched controls. We believe this to be a vitally
14 important element of developing female players given the distinct lack of published data per-
15 taining to this population in Africa.

16 Despite its novel contribution to the literature, it should be recognized that this study does have
17 some limitations. The utilized sample size was small, and thus, a larger sample would increase
18 the statistical power of the results. The pooling of data between North African countries could
19 have allowed us to understand, more precisely, the exact the characteristics of players from that
20 region, and to compare them to stronger African soccer nations such as Nigeria, Cameroon,
21 South Africa, Ghana, and Ivory Coast.

22 **6. Conclusion**

23 In summary, following a longitudinal follow-up after one season of soccer, the applied training
24 stimuli may explain increases in anthropometric, physical performance characteristics, agility,
25 and soccer skill of North African youth elite female soccer players, compared to a control group

1 of the same age. There were minimal changes in the non-athlete group and, therefore, any ob-
2 served changes in the soccer players could be attributable to their exposure to training. For
3 future investigations, a larger sample, including other age categories, and team sports would be
4 of major importance. Indeed, there has been very few published data on skill performance in
5 young elite female African soccer players compared to the extant literature on European play-
6 ers. Thus, we strongly advocat that North African researchers and coaches work more colle-
7 giately on women's soccer, with the aim of generating more data on anthropometric, physical,
8 technical, and tactical characteristics.

9 **7. Practical Applications:**

10 The anthropometric characteristics and physical fitness level of female players have been shown
11 to be important attributes for soccer performance. Therefore, this study provides baseline data
12 of youth North African female soccer players which is necessary for coaches to help with train-
13 ing prescription design. Accordingly, this could facilitate enhancements in the standard of
14 women's soccer on the continent and contribute to increasing the success of football.

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1 **Table 1.** Intraclass correlation coefficients (ICCs) for relative reliability and coefficients of
 2 variation for absolute reliability of the applied physical fitness tests.

Measures	ICC	95% CI	% CV	3
CMJ (cm)	0.983	0.970-0.990	4.62	
SJ (cm)	0.991	0.985-0.995	3.98	4
5JT (m)	0.979	0.963-0.988	3.77	
Speed 5 m (s)	0.879	0.790-0.931	4.36	5
Speed 10 m (s)	0.995	0.992-0.997	6.03	
Speed 30 m (s)	0.994	0.989-0.996	1.24	6
t-test without balls (s)	0.981	0.966-0.989	2.63	
t-test with balls (s)	0.974	0.955-0.985	3.65	7
LSPT TP (s)	0.939	0.893-0.965	3.54	
YYIRTL1 (m)	0.893	0.813-0.938	9.73	8

9 ICC intraclass correlation coefficient ; CI - confidence interval ; CV - coefficient of variation
 10 (%).

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Table 2: Anthropometric characteristics of female soccer group and control group determined at the beginning of the season (T1) and after 10 months (T2).

Variables	CG (n=26)			SG (n=26)			p-value (ES)
	T1	T2	ES	T1	T2	ES	
Height (cm)	156.5 ±8.2	157.6± 2.9	0.18	161.4±7.6 ^b	165.5±7.7 ^{ac}	0.54	<0.0001* (1.698)
Weight (kg)	59.7± 7.7	62.9±7. 2	0.43	60.4±8.4	66.4±7.7 ^d	0.75	<0.0001* (0.922)
BF (%)	26.5± 4.0 ^{ef}	29.2±3. 1 ^g	0.76	24.4±2.2	20.3±1.6 ^h	2.13	<0.0001* (3.112)

Data are presented as mean ± standard deviations. ES: Effect Size; BF: Body Fat; SG: Female Soccer Group; CG: Control Group. ^ap = 0.011 different from T1; ^bp = 0.004 different from CG at T1; ^cp < 0.0001 different from CG at T2; ^dp = 0.006 different from T1; ^ep = 0.001 different from T2; ^fp = 0.01 different from SG at T1; ^gp < 0.0001: different from SG at T2; ^hp < 0.0001 different from T1; *: significant differences between means for SG and CG.

Table 3: Jumping measurements for female soccer group and control group determined at the beginning of the season (T1) and after 10 months (T2).

Variables	CG (n=26)			SG (n=26)			p-value (ES)
	T1	T2	ES	T1	T2	ES	
CMJ	16.6± 0.8	17.2± 0.8	0.75	23.8± 4.4 ^b	26.9± 4.1 ^{ac}	0.73	<0.0001* (1.634)
SJ	12.4 ±0.4	13.2 ±0.4	0.20	20.5± 3.9 ^b	22.7 ±3.6 ^{cd}	0.59	<0.0001* (1.334)
5JT	6.6 ± 0.5	7.7 ± 0.5 ^a	0.22	9.3± 0.5 ^b	10.9 ±0.5 ^{ac}	0.32	0.004* (0.398)

Data are presented as mean ± standard deviations. ES: Effect Size; SG: Female Soccer Group; CG: Control Group; CMJ: Countermovement Jump; SJ: Squat Jump; 5JT: Five Jump Test. ^ap < 0.0001 different from T1; ^bp < 0.0001 different from CG at T1; ^cp < 0.0001 different from CG at T2; ^dp = 0.001 different from T1; *: significant differences between means for SG and CG.

Table 4: Sprinting, agility, skills and aerobic measurements for female soccer group and control group determined at the beginning of the season (T1) and after 10 months (T2).

Variables	CG (n=26)			SG (n=26)			p-value (ES)
	T1	T2	ES	T1	T2	ES	
S5 (s)	1.50 ± 0.11	1.50 ± 0.06	0	1.43 ± 0.51	1.40 ± 0.15 ^a	0.08	0.005* (0.387)
S10 (s)	2.90 ± 0.16	2.82 ± 0.15 ^b	0.65	2.12 ± 0.11 ^d	2.00 ± 0.13 ^{ce}	0.99	0.029* (0.238)
S30 (s)	6.32 ± 0.31	6.20 ± 0.27	0.41	5.20 ± 0.31 ^d	5.11 ± 0.28 ^e	0.31	0.006* (0.380)
T-test (s)	15.78 ± 0.69	15.54 ± 0.68	0.35	13.16 ± 0.76 ^d	12.04 ± 0.80 ^{ef}	0.82	<0.0001* (1.160)
T-test with Ball (s)	21.78 ± 0.76	21.50 ± 0.88	0.34	17.05 ± 1.12 ^d	14.94 ± 1.09 ^{ef}	0.91	<0.0001* (1.135)
LSPT (s)	91.58 ± 2.27	90.12 ± 2.03	0.68	78.59 ± 7.64 ^d	74.35 ± 5.04 ^{ce}	0.66	<0.0001* (1.126)
YYIRTL1 (m)	580.4 ± 70.9	645.5 ± 61.2 ^c	0.72	780.4 ± 124.9 ^d	990.8 ± 69.3 ^{ef}	0.99	<0.0001* (1.913)

Data are presented as mean ± standard deviations. ES: Effect Size; SG: Female Soccer Group; CG: Control Group; S5: 5m straight sprint; S10: 10m straight S5: 5m straight sprint; S30: 30m straight sprint; LSPT: Loughborough Soccer Passing Test; YYIRTL1: Yo-Yo Intermittent Recovery Test Level 1. ^ap = 0.003 different from CG at T2; ^bp = 0.04 different from T1; ^cp = 0.003 different from T1; ^dp < 0.0001 different from CG at T1; ^ep < 0.0001 different from CG at T2; ^fp < 0.0001 different from T1; *: significant differences between means for SG and CG.

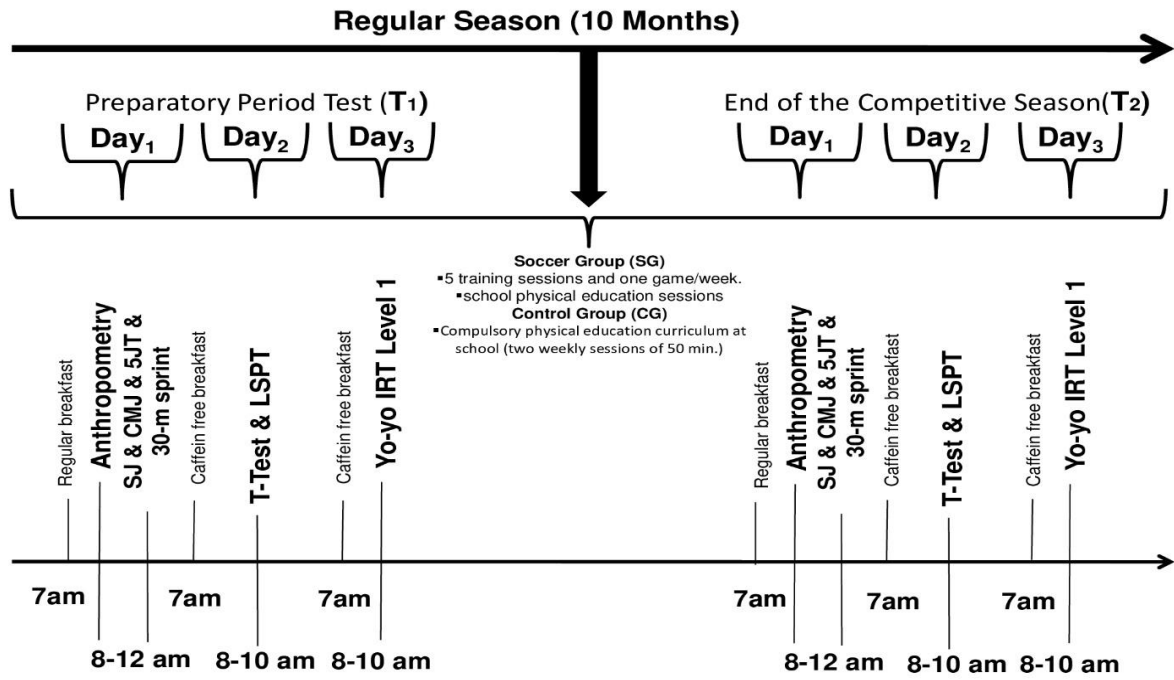


Figure 1: Study flowchart