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PHYSICAL FITNESS IN FEMALE SOCCER PLAYERS BY PLAYER POSITION: A FOCUS ON ANAEROBIC POWER

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ABSTRACT
Purpose. The aim of this study was to examine the relationship between player position and physical fitness, with an emphasis on anaerobic power, in female soccer players. **Methods.** For this purpose, 54 first league female soccer players were recruited. They included goalkeepers (*n* = 4, age 22.89 ± 4.37 years), defenders (*n* = 21, 21.92 ± 3.81 years), midfielders (*n* = 22, 21.71 ± 4.70 years) and attackers (*n* = 7, 20.43 ± 4.70 years). Participants' anthropometric characteristics were measured and a physical fitness test battery was administered. **Results.** Significant differences were observed in body fat percentage ($F_{3,50} = 3.06$, $p = 0.036$, $\eta^2 = 0.16$) with goalkeepers being fatter than defenders (mean difference 6.1%; 95% CI 0.3,11.9). Positional differences were also found in the sit-and-reach test ($F_{3,50} = 4.46$, $p = 0.007$, $\eta^2 = 0.21$), in which goalkeepers scored lower than defenders (–11.4 cm; 95% CI –21.4, –1.5) and midfielders (–10.0 cm; 95% CI –19.9, 0). Comparison of fat mass and endomorphy were statistically significant ($p = 0.057$ and $p = 0.062$, respectively), with goalkeepers showing the highest values; these differences were in the same direction as with body fat percentage. No positional differences were found in the other physical fitness components (aerobic capacity, anaerobic power, and muscle strength). **Conclusions.** Differences among player positions were observed in body composition (highest body fat percentage in goalkeepers) and flexibility (lowest score in goalkeepers). These trends are in agreement with previously published data concerning elite soccer players. These findings might be used as reference data by coaches and trainers to identify talent, select players, and monitor training.

Key words: body fat percentage, endomorphy, Wingate anaerobic test, playing roles, soccer

Introduction

In the daily practice of sport, profiling the physical and physiological characteristics of elite athletes helps coaches and fitness trainers identify talent, select players, and design appropriate training programs. Since female soccer players are assigned to a particular position, it is desirable to study their profile according to their role on the field.

Typically, soccer players are classified into four groups: goalkeepers, defenders, midfielders, and attackers [1–5], although another classification system has been used, grouping players into goalkeepers, central defenders, full backs, central midfielders, wide midfielders, and attackers [6]. These studies have revealed differences in the physiological characteristics depending on player position. It has been shown that defenders possess better aerobic capacity than goalkeepers, as indicated by scores calculated by running speed at the anaerobic threshold [1]. Wide midfielders were found to have better aerobic power than central defenders and attackers in a study using the Yo-Yo intermittent endurance test [6]. These positional differences in aerobic power are in agreement with corresponding differences during match play, where it has been noticed that midfielders cover larger distances than defenders [2]. In addition, research on young soccer players has shown that midfielders cover a greater distance than defenders, especially in low- and moderate-speed running, whereas attackers were recorded with higher values than midfielders in sprint distance, number of sprints, and maximum speed [5].

The contribution of the abovementioned research to our understanding of positional differences in female soccer is important, but there are several aspects that have not been fully examined and require further research. For instance, there are limited data on player position with regards to anaerobic power assessed by laboratory methods (e.g. Wingate anaerobic test and force–velocity test). Due to the physiological demands of match play, which includes many high-intensity activities of short duration (e.g. shooting, passing, sprinting, jumping), anaerobic power is important for soccer performance. Therefore, the aim of this study was to examine the relationship between player position and physical fitness, with an emphasis on anaerobic power, anthropometric characteristics, body composition, and somatotype.

Material and methods

First league female soccer players (*n* = 54) were recruited to participate in the study, classified according player position as: goalkeepers (*n* = 4, age 22.89 ± 4.37 years), defenders (*n* = 21, 21.92 ± 3.81 years), midfielders (*n* = 22, 21.71 ± 4.70 years), and attackers (*n* = 7, 20.43 ± 4.70 years) (Tab. 1). The study protocol was performed in accordance with the ethical principles outlined in the 1975 Declaration of Helsinki and approved by the local institutional review board. All measurements were taken in a single testing session during the 2009–2010 pre-season in laboratory conditions on weekdays between 08:00 and 12:00 (temperature 22°C and humidity 45%). Participants were measured for anthropometry, flexibility, aerobic capacity, muscle strength, and anaerobic power as follows:

Anthropometry

Body mass and height were measured to the nearest 0.1 kg by a HD-351 electronic weight scale (Tanita, USA) and to the nearest 1 mm using a portable stadiometer (SECA, UK), respectively. From these data BMI was calculated as the quotient of mass (kg) to height squared (m^2). During these measures, participants were barefoot and in minimal clothing. Based on the prediction equation of Parizkova [7], body fat percentage (BF) was estimated from the sum of 10 skinfolds (cheek, chin, chest I, triceps, subscapular, abdominal, chest II, suprailiac, thigh and calf; $BF = -41.32 + 12.59 \times \log_e x$, where x the sum of the 10 skinfolds). A two-component model of body composition [8] was used to divide body into fat mass (FM, equaling mass × BF) and fat-free mass (FFM, equaling mass – FM). We used the Heath-Carter method to evaluate somatotype according to the procedures described by Ross and Marfell-Jones [9]. Briefly, this method is used to quantify the shape and composition of the human body, expressed as a three-number rating representing endomorphy (relative fatness), mesomorphy (relative musculoskeletal robustness) and ectomorphy (relative linearity or slenderness). Chronological age for each participant was calculated using a table of decimals for the day of the year [9].

Sit-and-reach test (SAR)

To evaluate low back and hamstring flexibility, the SAR was performed using a box with a measuring scale in cm with 15 cm at the level of the feet [10]. The participants were instructed to sit on the floor with knees fully extended and to reach forward as far as possible. An experienced examiner ensured correct body position. This test was performed twice without shoes; the best result to the nearest 0.5 cm was recorded.

Physical working capacity at a heart rate (HR) of 170 bpm (PWC_{170})

The participants completed the PWC_{170} test, consisting of three 3-min consecutive stages of cycling at 1.0, 1.5 and 2.0 $W \cdot kg^{-1}$ on an 828E cycle ergometer (Monark, Sweden) [11]. The selected workloads were used to elicit HR between 120 and 170 bpm. Based on the linear relationship between HR and power output, PWC_{170} was calculated as the power corresponding to a HR of 170 bpm, expressed as W and $W \cdot kg^{-1}$. HR was recorded using a Team2 Pro heart monitor (Polar Electro Oy, Finland).

Isometric muscle strength

Isometric strength testing was performed for right handgrip, left handgrip, back, and back/leg strength [12]. In the handgrip test, players were instructed to squeeze the handle of a hand dynamometer (Takei, Japan) as hard as possible while standing with their elbow bent at approximately 90°. In the back test, players pulled the bar of a back dynamometer (Takei, Japan) at the level of the patella by straightening their legs and backs. In the back/leg test, players repeated the back test albeit with the chain length of the dynamometer adjusted to have participants squat over the dynamometer with their knees flexed at approximately 30°. The sum of these four strength measures was calculated to attain total strength in kg and as $kg \cdot kg^{-1}$ of body mass.

Force–velocity test (F–V)

The F–V test consisted of four sprints, each lasting 7 s and interspersed by 5 min recovery periods, against an incremental braking force (2, 3, 4, and 5 kg) on an 874E cycle ergometer (Monark, Sweden) [13]. This test was used to estimate maximal anaerobic power (P_{max}), expressed as W and as $W \cdot kg^{-1}$, theoretical maximal velocity (v_0), and theoretical maximal force (F_0).

Wingate anaerobic test (WAnT)

This test [13] was performed on the same ergometer as the F–V test. Briefly, the participants were asked to pedal as fast as possible for 30 s against a braking force that was determined by the product of body mass × 0.075. Peak power (P_{peak}) was estimated as the mean power over a 5 s period when the highest values were recorded, which occurred usually in the first 5 s of the test. Mean power (P_{mean}) was calculated as the average power during the 30 s period. Both P_{peak} and P_{mean} were expressed as W and $W \cdot kg^{-1}$. A fatigue index was also calculated to estimate the decrease in performance across the 30 s period and was expressed in %.

Statistical analysis

Data are expressed as means ± standard deviations. All the variables were tested for normality and the Kolmogorov–Smirnov test for equality of distribution. One-way analysis of variance (ANOVA) was used to examine the differences between goalkeepers, defenders, midfielders, and attackers. Measures of effect size (ES) in ANOVA were interpreted by eta-squared classified as small ($0.01 < \eta^2 \leq 0.06$), medium ($0.06 < \eta^2 \leq 0.14$), or large ($\eta^2 > 0.14$) [14]. The level of significance was set at $\alpha = 0.05$. SPSS 20.0 software (SPSS, USA) was used for all statistical analyses.

Results

The physical characteristics, body composition and somatotype of the participants by player position are presented in Table 1. We observed significant differences in BF percentage (large effect size) with goalkeepers being fatter than defenders, with a mean difference of 6.1% (95% CI 0.3, 11.9). In addition to the abovementioned parameter, the comparisons of the means of FM and endomorphy were statistically significant ($p = 0.057$ and $p = 0.062$, respectively; large effect size), with goalkeepers showing the highest values, and were in the same direction as the differences in body fat percentage.

The values for aerobic power, isometric muscle strength, and flexibility are shown in Table 2. Positional differences were found in the sit-and-reach test (large effect size), in which goalkeepers scored lower than the defenders (–11.4 cm; 95% CI –21.4, –1.5) and midfielders (–10.0 cm; 95% CI –19.9, 0). Table 3 presents the results of the WAnT and the F–V tests.

Discussion

The main finding of this study was the large effect of player position on BF and flexibility, including indications for an effect of a similar magnitude on FM and somatotype. Briefly, we observed that goalkeepers were fatter than defenders and scored lower in the flexibility test than defenders and midfielders. In addition, another finding that almost reached statistical significance ($p = \sim 0.06$) with a large effect size suggested that goalkeepers were more endomorphic and had more FM than defenders.

Interestingly, although not statistically significant, we noticed a trend of possible positional differences with regards to muscle power output. The largest positional difference in power (W) was observed in the F–V test (goalkeepers vs. midfielders ~135 W), where the highest score was achieved by goalkeepers (Fig. 1). Compared with the WAnT and PWC_{170}, the F–V test has the shortest duration but the highest intensity, taxing mainly the ATP–CP energy pathway. When we examined performance in the WAnT, which taxes mainly

Table 1. Physical characteristics, body composition, and somatotype by player position

	Goalkeepers ($n = 4$)	Defenders ($n = 21$)	Midfielders ($n = 22$)	Attackers ($n = 7$)	Comparison
Age (years)	22.89 ± 4.37	21.92 ± 3.81	21.71 ± 4.70	20.43 ± 4.70	$F_{3,50} = 0.36$, $p = 0.782$, $\eta^2 = 0.02$
Mass (kg)	66.5 ± 6.9	59.6 ± 5.4	60.6 ± 8.6	59.4 ± 8.6	$F_{3,50} = 1.19$, $p = 0.325$, $\eta^2 = 0.07$
Height (cm)	166.3 ± 6.1	164.8 ± 4.5	163.6 ± 7.4	163.8 ± 7.4	$F_{3,50} = 0.48$, $p = 0.482$, $\eta^2 = 0.03$
BMI (kg · m^{-2})	24.0 ± 1.3	21.9 ± 1.7	22.6 ± 2.7	22.2 ± 2.8	$F_{3,50} = 1.05$, $p = 0.379$, $\eta^2 = 0.06$
BF (%)	27.8 ± 2.6^{D}	21.7 ± 4.3^{G}	23.6 ± 3.7	22.3 ± 3.4	$F_{3,50} = 3.06$, $p = 0.036$, $\eta^2 = 0.16$
FM (kg)	18.6 ± 3.3	13.1 ± 3.6	14.5 ± 3.8	13.4 ± 3.8	$F_{3,50} = 2.67$, $p = 0.057$, $\eta^2 = 0.14$
FFM (kg)	47.9 ± 4.1	46.5 ± 3.0	46.1 ± 4.4	46.0 ± 5.4	$F_{3,50} = 0.25$, $p = 0.859$, $\eta^2 = 0.02$
Endomorphy	6.8 ± 0.7	4.7 ± 1.6	5.4 ± 1.3	4.9 ± 1.2	$F_{3,50} = 2.60$, $p = 0.062$, $\eta^2 = 0.14$
Mesomorphy	4.9 ± 1.5	4.4 ± 1.1	4.9 ± 1.4	4.0 ± 1.3	$F_{3,50} = 0.93$, $p = 0.434$, $\eta^2 = 0.05$
Ectomorphy	1.3 ± 0.9	2.3 ± 0.9	1.9 ± 1.4	2.1 ± 1.6	$F_{3,50} = 1.00$, $p = 0.401$, $\eta^2 = 0.05$

BMI – body mass index, BF – body fat percentage, FM – fat mass, FFM – fat-free mass; letters in superscript denote differences from the respective playing position (D – defenders; G – goalkeepers)

Table 2. Aerobic power, muscle strength, and flexibility by player position

	Goalkeepers ($n = 4$)	Defenders ($n = 21$)	Midfielders ($n = 22$)	Attackers ($n = 7$)	Comparison
PWC_{170} (W)	135 ± 24	131 ± 29	127 ± 28	137 ± 31	$F_{3,50} = 0.24$, $p = 0.865$, $\eta^2 = 0.01$
PWC_{170} (W · kg^{-1})	2.02 ± 0.23	2.21 ± 0.44	2.11 ± 0.47	2.28 ± 0.19	$F_{3,50} = 0.50$, $p = 0.685$, $\eta^2 = 0.03$
Right hand (kg)	33.9 ± 8.6	31.7 ± 4.6	30.5 ± 4.6	30.5 ± 4.3	$F_{3,50} = 0.68$, $p = 0.567$, $\eta^2 = 0.04$
Left hand (kg)	33.0 ± 4.4	29.2 ± 3.5	29.5 ± 4.6	26.9 ± 3.6	$F_{3,50} = 1.91$, $p = 0.139$, $\eta^2 = 0.10$
Trunk (kg)	95.4 ± 10.8	83.6 ± 13.7	85.1 ± 15.0	89.6 ± 14.6	$F_{3,50} = 0.96$, $p = 0.417$, $\eta^2 = 0.06$
Legs (kg)	131.6 ± 9.2	108.5 ± 25.9	106.2 ± 21.2	106.4 ± 31.0	$F_{3,50} = 1.30$, $p = 0.284$, $\eta^2 = 0.07$
Strength (kg)	293.9 ± 18.1	253.0 ± 42.4	251.5 ± 41.5	253.5 ± 40.2	$F_{3,50} = 1.29$, $p = 0.287$, $\eta^2 = 0.07$
Strength (kg · kg^{-1})	4.44 ± 0.40	4.26 ± 0.74	4.16 ± 0.52	4.26 ± 0.30	$F_{3,50} = 0.31$, $p = 0.822$, $\eta^2 = 0.02$
SAR (cm)	14.4 ± 4.8^{D,M}	25.8 ± 6.1^{G}	24.3 ± 7.1^{G}	19.1 ± 7.6	$F_{3,50} = 4.46$, $p = 0.007$, $\eta^2 = 0.21$

PWC_{170} – physical working capacity at 170 bpm, SAR – sit-and-reach test; letters in superscript denote differences from the respective playing position (D – defenders, M – midfielders, G – goalkeepers)

Table 3. Wingate anaerobic test and Force–velocity test scores by player position

	Goalkeepers (n = 4)	Defenders (n = 21)	Midfielders (n = 22)	Attackers (n = 7)	Comparison
P_{peak} (W)	658 ± 29	570 ± 63	577 ± 78	571 ± 85	$F_{3,44} = 1.37$, $p = 0.264$, $\eta^2 = 0.09$
P_{peak} ($W \cdot kg^{-1}$)	9.41 ± 0.24	9.50 ± 0.79	9.57 ± 0.78	9.44 ± 0.70	$F_{3,44} = 0.07$, $p = 0.974$, $\eta^2 = 0.01$
P_{mean} (W)	489 ± 14	423 ± 48	432 ± 50	426 ± 59	$F_{3,43} = 1.60$, $p = 0.204$, $\eta^2 = 0.10$
P_{mean} ($W \cdot kg^{-1}$)	7.00 ± 0.06	7.07 ± 0.83	7.21 ± 0.70	7.07 ± 0.87	$F_{3,43} = 0.14$, $p = 0.934$, $\eta^2 = 0.01$
FI (%)	47.5 ± 6.4	47.8 ± 10.2	44.2 ± 7.1	44.1 ± 4.9	$F_{3,43} = 0.72$, $p = 0.545$, $\eta^2 = 0.05$
P_{max} (W)	844 ± 135	768 ± 121	709 ± 78	785 ± 127	$F_{3,45} = 2.25$, $p = 0.096$, $\eta^2 = 0.13$
P_{max} ($W \cdot kg^{-1}$)	12.68 ± 1.35	12.84 ± 1.96	11.93 ± 1.73	13.22 ± 1.46	$F_{3,45} = 1.25$, $p = 0.303$, $\eta^2 = 0.08$
V_0 (rpm)	188 ± 14	182 ± 12	187 ± 13	188 ± 12	$F_{3,45} = 0.65$, $p = 0.584$, $\eta^2 = 0.04$
F_0 (kg)	18.1 ± 3.7	17.0 ± 3.2	15.2 ± 2.0	16.8 ± 3.4	$F_{3,45} = 1.78$, $p = 0.165$, $\eta^2 = 0.11$

P_{peak} – peak power, P_{mean} – mean power, FI – fatigue index, P_{max} – maximal power, v_0 – theoretical maximal velocity, F_0 – theoretical maximal force

the anaerobic glycolytic energy transfer system, the highest value was again scored by goalkeepers, but there were smaller positional differences than in the F–V test (goalkeepers vs. defenders ~66 W). This difference was almost negligible in the PWC_{170}, a test of the aerobic energy transfer system, where the largest difference was ~10 W (attackers vs. midfielders). This trend might be attributed to the positional-specific actions of goalkeepers during match play and training, which are of high intensity and short duration.

In contrast, we did not find a similar trend as above when muscle power output was expressed in $W \cdot kg^{-1}$ (Fig. 2), where the highest scores were not found in goalkeepers but in outfielders. The widest range of differences was ~1.29 (attackers vs. midfielders) for P_{max}, ~0.21 $W \cdot kg^{-1}$ (midfielders vs. goalkeepers) for P_{mean}, and ~0.26 $W \cdot kg^{-1}$ (attackers vs. goalkeepers) for PWC_{170} $W \cdot kg^{-1}$. It seems that the increased mass in goalkeepers, even if it is due to increased FM, provides this group with an advantage in terms of power output over outfielders (when expressed as an absolute value, i.e. W). However, when we took into account mass, with these parameters expressed in $W \cdot kg^{-1}$, the effect of player position was reduced or reversed. This may be due to the fact that anaerobic power was tested with two widely used and traditional protocols (WAnT and F–V test) on a cycle ergometer. In this mode of exercise, mass is supported by the ergometer and might mask the negative effect of excess mass, whereas in running, excess mass must be carried and therefore may affect performance.

Since this is the first study, to the best of our knowledge, investigating the relationship between player position and anaerobic power with the WAnT in a population of female soccer players, there were no data to compare our findings. However, when compared with normative data on intercollegiate high-level female athletes [15], P_{peak} and P_{mean} (W) were evaluated as “above average” in goalkeepers and “average” in outfielders,

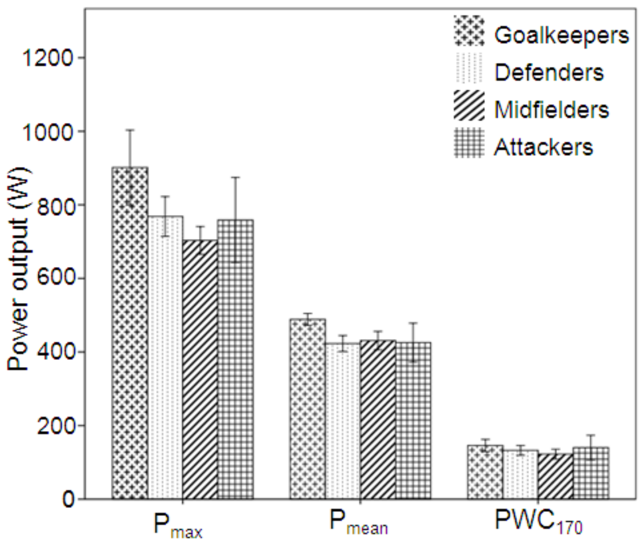

Figure 1. Power output (W) in the three tests by player position: Force–velocity test (P_{max} – maximal power), Wingate anaerobic test (P_{mean} – mean power), and physical working capacity at a heart rate of 170 bpm (PWC_{170})

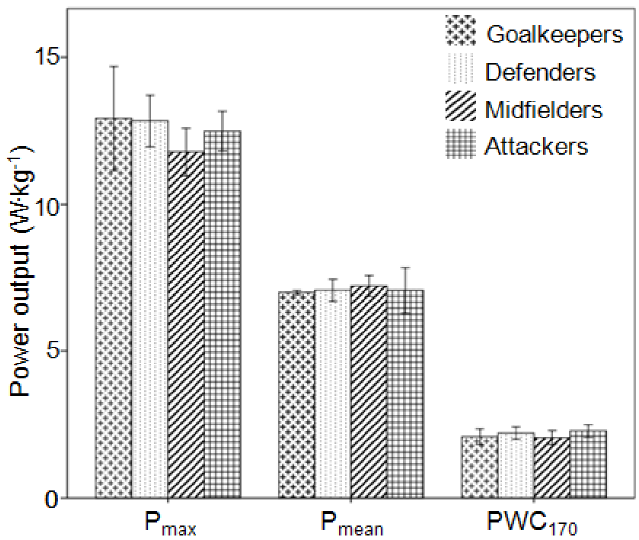

Figure 2. Power output ($W \cdot kg^{-1}$) in the three tests by player position: Force–velocity test (P_{max} – maximal power), Wingate anaerobic test (P_{mean} – mean power), and physical working capacity at a heart rate of 170 bpm (PWC_{170})

whereas they were "average" for all player positions when expressed as $W \cdot kg^{-1}$.

These findings have practical implications for soccer performance, as previous research has indicated that the scores in the WAnT and in the F–V test might be predictive of athletic performance. For instance, the indices of the F–V test have been shown to correlate with indices of soccer performance [16–18]. In research on young male soccer players [16], P_{max}, v_0, and F_0 were correlated with acceleration during a 5 m sprint, whereas research on sprinters [17] found P_{max} correlated with performance in a 10 m sprint. Moreover, P_{max} was correlated with jumping ability, indicating its affinity with leg muscle strength [18]. It has been also found that the F–V test can classify male soccer players depending on their age, with older soccer players scoring higher values than their younger counterparts [19]. The main indices of the WAnT (P_{peak} and P_{mean}) have also been shown to correlate with sprint performance, especially when expressed in $W \cdot kg^{-1}$ [20].

Surprisingly, goalkeepers scored lower in the sit-and-reach test than defenders and midfielders, and the overall performance of all positions was below average. Although flexibility is a component of physical fitness in which women score higher than men, our findings were comparable with those of male soccer players [21]. These results highlight the need for flexibility training in our sample of female soccer players especially for goalkeepers. Among outfielders the lowest score was recorded in attackers, which is in agreement with research on positional differences in male soccer players [22] and might be attributed to the lower number of direction changes they perform during play.

The main drawback of this study was that the sample size was inadequate to provide statistically significant findings even in cases where a moderate or large effect size was indicated by eta squared. Although the total number (n = 54) of soccer players was one of the largest ever studied in female soccer, two groups (goalkeepers, n = 4, and attackers, n = 7) were relatively underrepresented. This has been a frequent limitation in previous studies that have examined positional differences in female soccer players [1–4], where the samples of participants ranged from n = 17 [2] to n = 29 [1] and the sample of goalkeepers was quite small (e.g. n = 3 [1, 4], n = 2 [3]). On the other hand, this is the first study to report data on the anaerobic power of female soccer players using two laboratory methods (WAnT and F–V test) by player position and, therefore, might serve as normative data in future research.

Conclusions

Differences between player positions were observed in body composition (highest body fat percentage in goalkeepers) and flexibility (lowest score in goalkeepers). These trends are in agreement with previously published data concerning elite soccer players. Although no positional differences were found between the groups for anaerobic power, these findings might be used as reference data by coaches and trainers to identify talent, select players, and monitor training.

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