Effects of Positional Differences and Dual-task on Balance Performance of Saudi Soccer Players

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Abstract: In this study, we investigated the dynamic balance of young amateur soccer players to understand how dual-task and playing position influence postural control. Thirty-six national level players [goalkeepers (GK), defenders (DF), midfielders (MF) and forwards (FW)] were tested using a stability platform, in both eyes open (EO) and eyes closed (EC) condition during single (ST) and dual-task (DT) conditions. The root-mean-square error (RMSE) of the stability platform angle was calculated and used as outcome measure. The results showed that playing positions did not influence balance performances except in the EO/ST condition. In such conditions, GKs reported better balance scores compared to other players. However, the RMSE values significantly decreased during the DT condition in comparison to the ST condition only in the EC condition for GKs ($p<0.05$), but not for the FW, MF and DF. In conclusion, balance performance did not vary with playing position in soccer players. However, the GKs showed significantly worse balance performance ($p=0.024$; 95% CI [0.33, 5.21]) in challenging postural conditions, DT condition with EC compared to ST/EC condition).

Keywords: Postural balance, dynamic balance, dual-task, soccer, playing position.

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1. Introduction

Football (soccer) is one of the most widely played sports with almost 300 million registered players in the world [1]. It is a multifactorial sport composed of several actions which require the maintaining of postural balance [2]. Postural balance is the ability to maintain, achieve and restore a state of balance during any posture or activity [3]. Particularly, dynamic balance is defined as the ability to maintain the body's center of mass whilst performing movement [4] or a functional task [5]. For soccer players, it represents a key factor in achieving optimal performance and reducing the risk of injuries and an indicator of performance in playing football [6]. Indeed, many game situations like dribbling, sudden changes in direction, especially under acceleration/ deceleration conditions, landing after jumps, etc. are better performed in the presence of well-developed body control [7]. Besides, when shooting and passing the ball over various distances, jumping or changing direction, soccer players require an excellent balancing capability in order to execute the desired skill and movement and in order to avoid instability and poor technique [8,9]. It has been suggested that low balance ability in soccer players increases the risk of ligament injuries [10], and may represent a predictive factor for lateral ankle sprains [11,12]. Multiple studies have reported a significant association between balance loss and injury [13,14]. Therefore, an appraisal and periodic monitoring of static and dynamic balance in soccer players can be an important way to correctly define and update training programs and the rate of improvement in balance scores over time. This would allow for maximizing, in each period of the athlete's body development, the coherent creation and optimization of a wide set of fundamental motor abilities [15].

In this respect, there are specific issues that still appear scarcely explored such as, for example, the influence of the playing position on postural balance. Only a few studies have investigated balance performance of soccer players dependent upon their playing positions. Soccer players are generally categorized into four positions: goalkeepers (GK), defenders (DF), midfielders (MF) and forwards

(FW) [16]. In this context, Pau et al., 2014, compared static balance among DF, MF and FW players and found that MF exhibited significantly lower sway values in static balance compared to DF [17]. Also, a recent study by Mahmoudi et al., 2023, found that GK exhibited better static and dynamic balance compared with other players, and MF showed better dynamic balance than DF and FW [18]. It was suggested that the evaluation of postural control performance should be considered a relevant part of the position-specific functional evaluation of soccer players [18]. In contrast, Jadczak et al. (2019) categorized soccer players into six positions and reported no significant differences in static balance with eyes opened between positions [6]. Similarly, it has been revealed that, when the base of support was kept stable, no differences between FW and DF groups were observed [19]. On the contrary, when posture was perturbed by introducing a displacement of the platform and eliminating visual input, DF appeared to be characterized by superior postural stability compared to FW [19]. It has been also proved that MF had better static balance than GK and greater dynamic balance compared to DF, external midfielders and FW [6], suggesting that the effects of playing positions on postural balance depend on the sensory condition.

In combination, soccer is a sport characterized by multiple physical fitness, and tactical, technical and mental components demands, involving acceleration, changes in direction, deceleration and struggle [20]. Soccer players are exposed to both cognitive and motor difficulties at the same time during the match and training. Indeed, soccer requires players to simultaneously process more than one source of information while displaying their skills [21], which are defined by dual-task. During the match, the player has to decide and perform the best action (passing, dribbling, shooting, misleading the opponent, avoiding incoming external forces, preparing positions for his friends, positioning on the field, and viewpoint, etc.) as soon as possible [20]. Soccer players who display superior performance in processes related to such dual-task performances also maximize their performance by making the right moves [22]. However, despite the importance of dual-task in soccer, we have not found any studies in the literature examining balance performance and dynamic postural priority while performing dual-task according to playing positions in soccer.

Considering that determining position-specific balance characteristics is important for both the talent identification and development processes of optimizing the athlete's fundamental motor skills [18], it appears of interest to clarify whether the playing position is somehow associated with superior postural control system performances mainly while performing dual-task or not. Thus, the aim of the present study is to investigate possible differences in dynamic balance between different soccer positions. Based on the different physical characteristics and specific soccer skill requirements, we hypothesized that different positions would influence dynamic balance measures even in challenging conditions.

2. Materials and Methods

2.1. Participants

According to Beck, G*power software (version 3.1.9.2; Kiel University, Kiel, Germany) [23] was used to calculate the required sample size. Values for power, correlations among repeated measures over group, and the non-sphericity correction (ε) were set at 0.95, 0.5, and 1, respectively. Based on the data of a study exploring the effects of DT among athletes [24], we estimated an effect size of f= 0.77. This calculation led to a required sample size of at least 10 participants in order to minimize the risk of Type II statistical error (Cohen, 1988). We recruited 36 volunteers' amateur soccer players, with respect to the inclusion and exclusion criteria, from regional league football club to participate in our study.

The participants were healthy amateur Saudi male soccer players competing at national level (19.94±0.81 years, 174.28±3.91 cm, body mass = 63.86±6.45 kg) in four playing positions (GK (n=6), DF (n=17, MF (n=6) and FW (n=8)).

The participants had at least four years of experience playing soccer at a amateur level with regular training on a given position. Regular active participation (≥75% of the team's total time of match play in the most recent season) in the 3nd and 4rd young Division Saudi Aribia football league and regular participation in training sessions (at least 5 times in a week) were the two most crucial selective criteria for the volunteers.

Players who had a history of cerebral concussion, visual or vestibular disorders, injury to either ankle, lower extremity injuries for 3 months before testing, ear infection, upper respiratory infection, or head cold at the time of the study were excluded.

All participants were verbally informed of the purpose, procedures, and risks associated with the study, their freedom to withdraw at any time without prejudice and if they agreed, they signed the consent form. The study was carried out according to the Declaration of Helsinki and the ethical approval for the study was granted by the Local ethical Committee, the Institutional Review Board of King Saud University at (No. KSU-HE-23-1229).

2.2. Study Design

The participants were invited to the laboratory, at the same time of day, in one familiarization session and one testing session. In the familiarization session, 3 days before the beginning of the experimental protocol, all tests were clearly verbally explained by the trained experimenters in order to eliminate the fear of new material. To ensure that they were familiarized with the experimental protocol, participants were also given a short trial for each task. The second visit was the testing session in which we evaluated participants 'dynamic postural balance, via a stability platform (Stability Platform, Model 16030 L, Lafayette Instrument Company, Lafayette, IN, USA, Figure 1), in an upright bipedal stance during different conditions; eyes opened (EO) /eyes closed (EC) conditions in single (ST) and dual-task (DT) conditions in a randomized order.

In the ST, participants performed only the dynamic balance task, while in the DT, they practiced the dynamic balance task and concurrently performed the cognitive task (i.e., serial three subtractions) for 30s. To analyze DT interference, the DT cost (DTC) of the standing performance was calculated using the following formula (Fabri et al., 2017): DTC %= [(DT-ST)/ ST] ×100.

2.4. Dynamic balance Measurement

Dynamic balance performance was assessed using a stability platform (Stability Platform, Model 16030 L, Lafayette Instrument Company, Lafayette, IN, USA). The stability platform consists of a 65 × 107-cm wooden platform, that allow a maximum deviation of 15° from the horizontal to either side of the platform (Figure 1). A safety rail mounted to the stability platform was used to prevent participants from falling if they lost their balance. The platform has been previously used in previous studies on balance to assess dynamic balance [25,26]. Participants were instructed to remain in balance, i.e., to keep the unstable surface (maximum deviation of 15°) of the platform as long as possible in a horizontal position, ±3° deviation to each side of its horizontal alignment, during each 30-s trial in both vision conditions (EO/ EC) during ST and DT conditions (Figure 1).

Each trial started with the platform in horizontal position and arms grasping the safety rail. Approximately 15 s before the start of a trial, the experimenter asked the participant to step on the platform with their regular shoes. About 3 s before the start of a trial, the experimenter provided the starting number for the serial subtraction task to the participants. At the start signal, the participants attempted to move the platform, and data collection began. These data were collected by two examiners who were not involved in data analysis in order to prevent experimenter bias. Consequently, the data of the platform positions were exported from the analysis software PsymLab and used to calculate the root-mean-square error (RMSE) in degrees.

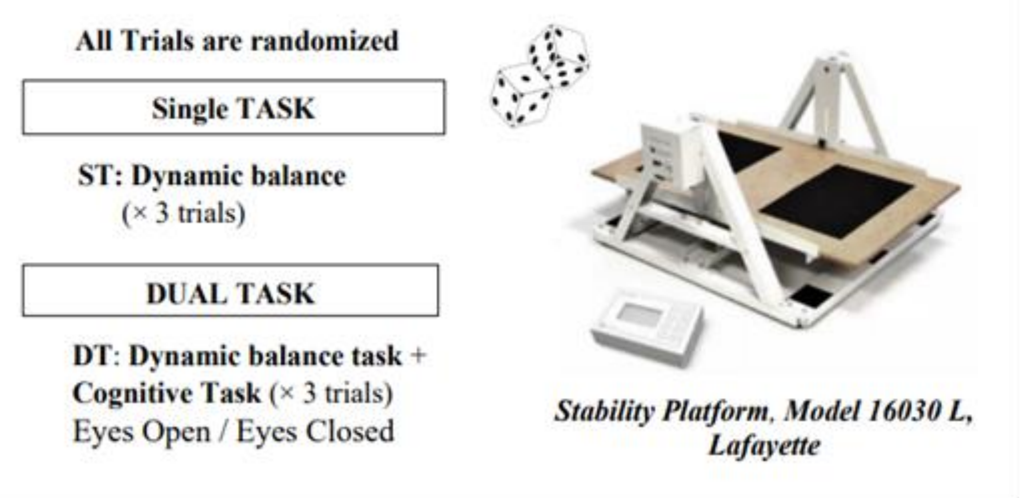

Figure 1. Study Design illustration

2.5. Statistical analysis

All variables were computed as mean and standard deviation (SD). All data sets were initially tested for normality and homoscedasticity of variance using the Kolmogorov-Smirnov test and Levene test, respectively.

The RMSE values differences between positions on the field (GK, FW, DF and MF) were analyzed using a three-way repeated measures analysis of variance (ANOVA) [(2 task conditions: ST motor, DT motor-cognitive Tsk) × (2 visual conditions: EO/ EC) × (4 playing positions: GK/ FW/ MF/ DF)]. The DTC between playing positions and vision condition were compared using a two-way repeated measured ANOVA [(2 visual conditions: EO/ EC) × (4 playing positions: GK/ FW/ MF/ DF)]. When a difference was significant, post hoc statistical analysis were performed using the Fisher LSD test. Effect sizes for the main and interaction effects were calculated using the partial eta squared ($\eta p2$) formula (small: $0.01 < \eta p2 < 0.06$; moderate: $0.06 < \eta p2 < 0.14$; large: $\eta p2 > 0.14$) [27]. Additionally, A 95% CI was performed for each comparison.

All analyses were performed using the software STATISTICA 12 (StatSoft, France) and a significance level was set at $p < 0.05$.

3. Results

The three-way repeated measures ANOVA revealed a significant main effect of the task factor ($F (1,32) = 4.20$, $p=0.04$, $\eta 2p=0.12$) on the RMSE scores with large effect size (Table 1). However, no significant main effects of vision or playing positions factors as well as no interactions between factors were found (Table 1). Concerning the task effect, the post-hoc analysis showed that the RMSE values increased significantly during the DT condition in comparison to the ST condition (with a DT cost of 51.48%) only in the EC condition for GK position ($p=0.024$; 95% CI [0.33, 5.21]), but not for the FW, MF and DF (Table 2 and Figure 2). Besides, the Bonferroni corrections showed that the RMSE scores were significantly lower for the GK compared to other playing positions in the EO/ST condition (vs DFs: $p=0.04$, 95% CI [-0.18, 4.69], vs the FWs: $p=0.03$, 95% CI [-5.99, -0.18]). For the vision factor, no significant effects were found between EO and EC conditions in both ST and DT for all the playing positions (Table 2 and Figure 2).

Table 1. Summary of ANOVA results of the balance parameter (RMSE) variables statistics values (F, p, η^2_p) in young soccer payers

	F	p-value	η2p
RMSE			
Task condition	4.60	0.03	0.13
Vision condition	0.43	0.51	0.01
Playing position condition	1.00	0.40	0.86
Task × Vision interaction	0.51	0.51	0.48
Task × Playing position interaction	1.10	0.36	0.09
Vision × Playing position interaction	1.14	0.35	0.09
Task × Vision × Playing position interaction	0.59	0.62	0.05

Table 2. Mean ± SD of the Root-mean-square error (RMSE) of the stability platform angle for different paying positions [goalkeepers (GK), defenders (DF), midfielders (MF) and forwards (FW)] in both eyes open (EO) and eyes closed (EC) conditions during single (ST) and dual-task (DT) conditions.

	GK		**MF**		**DF**		**FW**	
	EO	**EC**	**EO**	**EC**	**EO**	**EC**	**EO**	**EC**
RMSE								
ST	7.24± 2.23	8.28 ± 2.99	8.54± 1.99*	9.81± 1.53	8.24± 2.30*	12.02± 3.20	10.16± 1.83	9.47± 2.40
DT	8.85± 3.16	11.16± 1.57#	8.59± 1.78	11.63± 2.83	9.95± 2.78	9.50± 2.53	10.76± 3.55	10.12± 2.844
DT cost (%)	30.43± 65.54	51.48± 57.91	13.50± 28.11	23.01± 42.90	13.89± 44.48	9.59± 43.32	0.07± 19.28	2.37± 17.35

* Significant difference compared to GK at p <0.05.

\# Significant difference between ST and DT at p <0.05

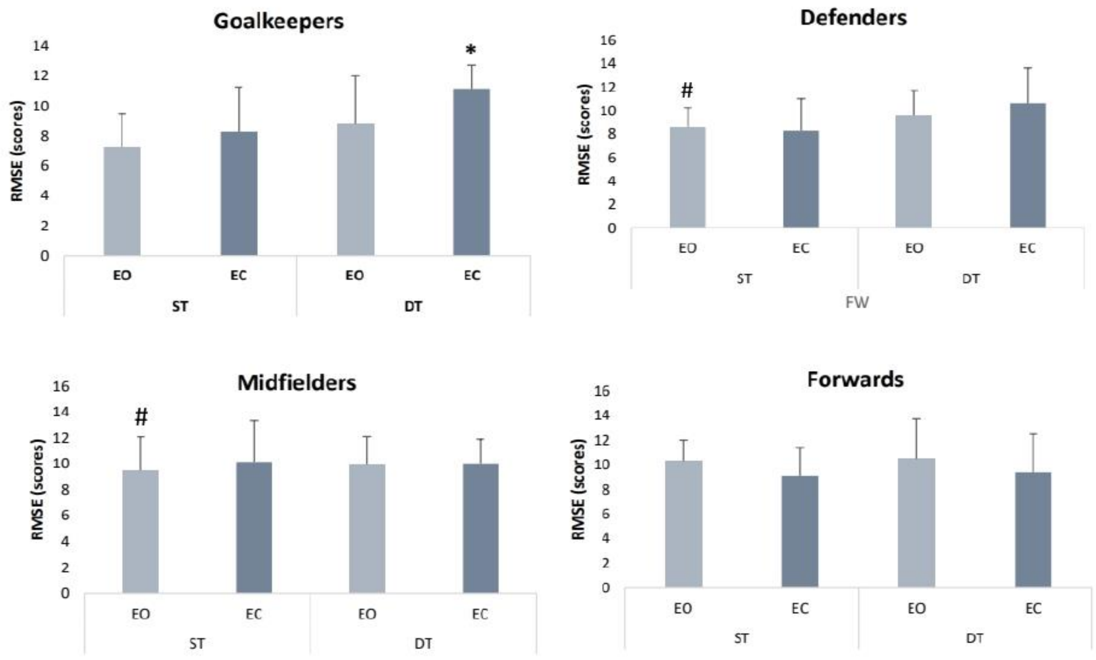

Figure1. Dynamic balance parameter (Root-mean-square error (RMSE) of the stability platform angle) for different paying positions [goalkeepers (GK), defenders (DF), midfielders (MF) and forwards (FW)] in both eyes open (EO) and eyes closed (EC) conditions during single (ST) and dual-task (DT) conditions.

** Significant difference between ST and DT at p<0.05. # Significant difference compared to GK at p <0.05.*

4. Discussion

In this study, we compared balance profiles for soccer players across different playing positions during ST and DT condition. Our major findings revealed that (i) the GK payers showed higher balance skills compared to their peers in the simple postural condition (during ST with EO) and that (ii) DT effects on balance performance depends on the playing positions and vision condition. In fact, a significant decline in balance performance during DT compared to ST condition for the GK players only when their vision inputs are deprived. However, for the FW, DF and MF, no significant differences between ST and DT were detected in both EO/EC conditions.

Firstly, GKs demonstrated notably higher balance skills compared to players in other positions, especially evident in the simple postural condition (during ST with EO. It has been revealed that playing in a specific field position and performing well-defined technical tasks, that imply characteristic physical actions, appears to influence the effectiveness of the postural control system [17]. Besides, it has been evidenced that GKs had better orientation ability, reaction ability and balance ability than their counterparts (i.e. DF, MF and attackers) which may explain their exceptional postural control abilities [28]. Particularly, similarly to our findings, Nurtekin Erkmen et al. (2016) indicated that Goalkeepers seem to have better visual balance skills suggesting that GKs show faster and more efficient adaptation to a novel whole body visuomotor rotation compared to non-athletes [29]. This may, therefore, explain the optimal balance performance of the GK players found in the EO condition. In contrast, Jadczak et al. (2019) categorized soccer players in six positions and found no significant differences in static balance with eyes opened between positions. But, in the EC condition, MF had greater dynamic balance compared to DF, MF and FW [30]. The conflicting results may be explained by the fact that the difference between distances traveled by athletes and the related fatigue levels has been reported to influence balance performance [31].

Importantly, postural control is maintained through the integrative process of afferent sensory information provided by the visual, vestibular, and somatosensory systems. When visual input was perturbed, participants relied on vestibular and proprioceptor inputs to control their balance which increased sway patterns [32,33]. However, our findings suggest that visual manipulation did not influence dynamic balance regardless of a player’s positions, which may be due to greater sensitivity of sensory receptors or better integration of information reported for players with more frequent and intensive training sessions [34]. Specifically, general muscular exercises prevalent in football training, such as running and walking, are likely to influence the effectiveness of sensory inputs [35]. Indeed, footballers appeared to rely more heavily on signals from the vestibular system, recognized as the most reliable source of information regarding the body's center of gravity positioning [36]. Hammami et al. (2014) proposed that learning to rely on sensory inputs other than vision, such as those from the vestibular system, may enhance an individual's posture balance, particularly in situations where vision is limited [37].

Furthermore, in this study, we compared dynamic balance under the

ST and DT conditions among soccer players of different positions. As results, no significant differences between ST and DT were detected for the FW, DF and MF players. Our findings are in line with prior research on the postural control of skilled athletes [5,38,39], which suggests that skilled athletes exhibit superior postural skills in diverse postural conditions particularly under DT conditions. The observed superiority of skilled athletes in our experiment may be attributed to their regular balance training in everyday activities. Such training modality likely enhances neuromuscular coordination and joint strength, potentially contributing to improved postural abilities [40]. Previous studies have indicated that shifting the focus of overt attention away from postural control could paradoxically improve it by reducing interference from highly automated tasks [41,42]. Our results suggest that skilled athletes may allocate attentional resources more effectively, enabling them to discriminate presented stimuli better as postural difficulty increases. This flexible allocation of attentional resources at the early processing stage implies a deliberate strategy employed by athletes to enhance discriminability, further underscoring the importance of highly practiced postural control in skilled athletes. One potential explication is that soccer playing involves ongoing and changing attentional demands. Indeed, the dynamic nature of this sport requires expert soccer players to quickly process information and make several decisions in a short period of time which may explain athletes' best focus and subsequent performance during challenging conditions (like DT) [43].

Alternatively, our findings indicated that for GKs, when their visual input is perturbed (in the EC condition), that dynamic balance performance significantly decline during DT compared to ST conditions. This finding suggested that the reliance on visual information plays a crucial role in maintaining dynamic balance for GKs, particularly when faced with additional cognitive demands. When visual inputs are disrupted, such as in the EC condition, GKs seems to experience greater difficulty in integrating sensory information and coordinating movement, leading to a decline in balance performance during dual-tasking. This highlights the importance of visual feedback in the postural control of GKs and underscores the potential challenges they face when visual inputs are compromised [44], especially in dynamic situations where rapid adjustments are required.

One of the limitations of the current study was the non-report of determinant co-variables (such as attention) of players that may helped to explain the evidence of differences between GKs and other playing positions. Additionally, the use of only one specific competitive level “amateur” must be carefully considered in the interpretation of the results, since are not representative of competitive levels. Future studies should increase the number of players involved per playing position and sample size for increasing the possibility of generalization of the findings. Finaly, since most soccer players often performed unilateral actions, such as kicks, passes and movements to change the running direction, it would be interesting to evaluate the DT effects in unipedal standing position.

5. Conclusions

Our study clarified the nuanced relationship between playing positions and balance performances among soccer players. Notably, our findings showed that GKs exhibit superior balance skills compared to their peers (FW, FD and MF), particularly evident in the simple postural condition (EO/ST). Moreover, the impact of dual-tasking on balance varies across positions, with GKs experiencing a significant decline in balance performance during DT only when visual inputs are deprived. These findings underscore the importance of considering the specific demands of playing positions and vision conditions in assessing balance abilities in soccer players. Moving forward, tailored training programs and injury prevention strategies should account for these positional differences and vision conditions to optimize performance and mitigate injury risk.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

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