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Assessment of Football Players Aerobic Endurance Using the Footeval Test: A Quasi-experimental Study Design

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Abstract: Individual physical and physiological capabilities in football are key for players to be successful. Measuring and monitoring a player's physical fitness is important and is achieved by football-specific tests which play a vital role in determining fitness levels for both individual and collective team behavior. The aim of this study was to assess the level of aerobic endurance among elite male football players at different play positions participating in the Football Association of Zambia (FAZ)/Eden University sponsored 2020/2021 National league season. The main instrument of data collection was the Footeval aerobic endurance test (FAET). Data was analyzed descriptively and compared using STATA version 13. One-way analysis of variance ANOVA was used to test the difference between the means of independent groups for independent variables at a statistical significance of 5%. Participants mean (±sd) of age, height, and body mass (BM) were 22.2 (±2) years, 1.70 (±6.62) m and 68.4 (±10.2) kg respectively. Their average physiological parameters were at least; resting heart rate (RHR) 48 b/min, maximum heart rate (MHR) 186 b/min, and maximum oxygen uptake (VO_{2max}) at 61.5 ml/kg/min for the whole population. This study demonstrated that volume of oxygen uptake gradually increased from the baseline to mid and all the way to post-test at different play positions amongst players. Adaptation of the test was therefore recommended for fitness evaluation and future research in aerobic endurance testing with focus on the current establishment of football in Zambia.

Keywords: Footeval Test, Aerobic Endurance, Football, Fitness, Play Position, Maximum Oxygen Uptake, Body Mass

1. Introduction

Soccer is the world`s most popular sport with approximately 265 million players and 5 million referees and officials actively involved, translating to 4% of the world population according to Haram and Lee [1]. Carling, Gregson, McCall, Moreira and Del highlighted that the game is intermittent in nature and involves multiple motor skills, such as running, dribbling, kicking, jumping, and tackling. Good performance depends upon a variety of individual skills and the player's interaction and integration within the team. It is in review of literature that measuring and monitoring the player's physical fitness is important for the team, the technical bench, and the health authorities [2]. This is because football players operate on average at about 70% of their maximum oxygen uptake, at about 80-90% of the maximum heart rate, with a blood lactate of 2-10 mmol/l while they cover approximately 8-12 km distance during a professional football match as reported by Arnason, Sigurdsson and Gudmundsson [3]. Therefore, Pye and Miller indicate that football specific performance tests play a vital role in determining the fitness levels of both individual and collective teams [4]. However, for the Footeval test to be reliable in assessment of aerobic endurance, the tools should have acceptable measurement properties such as being clinically feasible, being readily available and easy to perform, requiring no or only portable equipment, and should be time efficient.

The Footeval Test is one such specific aerobic test used to evaluate physical performance. Manouvrier et al [5] stated that it is an incremental and intermittent football (soccer) specific test based on the twenty-meter shuttle test, although it incorporates dribbling of the soccer ball and a 30 second rest period after every minute. In addition, the Footeval Test is based on the spatial organization of Léger's "20m shuttle run" test Léger and Lambert, to include direction changes at 180° [6]. The purpose of this test was to determine a global index of football players, providing a clear idea of their level of aerobic endurance, including physical and technical skills. Notation considers players' aerobic power and technical capacity in real football conditions indicating their Maximal Aerobic Speed (MAS). Earlier, Ziogas G, G. Patras, Stergiou and Georgoulis highlighted that this test allows Maximal Oxygen Uptake (VO_{2max}) to be measured in specific conditions and will be influenced by many factors such as running economy, muscular ability, or technical skills with the ball, differentiating football players according to their level of aerobic endurance [7].

Although football-specific performance tests are necessary for determining a player's and a team's fitness levels, they appear to be underutilized, and there are no protocols in place for this athletic community here in Zambia. This has left a gap in the evaluation of the assessment and outcome of aerobic endurance testing regarding performance among football players in Lusaka province. Dellal, Hill-Haas, and Chamari also highlighted that in football, aerobic fitness is one of the most important attributes of the game and throughout the years test protocols have been established in most football clubs around the world to assess the level of endurance among players [8]. However, Bradley et al stated that individual physical and physiological capabilities (both aerobic and anaerobic) must also reach a certain level for players to be successful. Without aerobic endurance, running economy, and muscular ability, technical skill with the ball often becomes a problem leading to football injuries and poor performance [9]. This study aimed to provide information on the levels of fitness, evaluate physical performance among football players in division one football clubs and draw recommendations for aerobic endurance training using FAET outcomes. The division one national league is one of the competitive football leagues in the country hosted annually and comprising 18 participating football clubs. Further, it was believed that information collected would add to the body of knowledge and create a foundation for research needs.

2. Materials and Methods

2.1. Participants

A quasi-experimental study design in which cases were used as their own controls was conducted to compare the aerobic endurance of each team. The key concerns included cross-contamination between teams due to the nature of the test (intervention) as the participating teams were located relatively close to each other. The study was approved by ERES CONVERGE IRB Research Ethics Committee (Reference No. 2021-Sep-015) and all participants signed the consent form. In addition, all participants were within this region and using teams from other regions would not have been comparable in many aspects such as club level, governance and administration, financing and sponsorship, technical bench setup, and availability of qualified medical officers and paramedics, sporting infrastructure and geographical location. The study was conducted in Lusaka, at the respective home grounds of the National League teams from FAZ Division I League.

2.2. Influential Factors That Need Control

Tests carried out in the field have the advantage of being easily reproduced anywhere whilst requiring minimal equipment. Hence, field-based evaluations were delivered under standardized conditions to improve reliability. This includes standardization of the surface and environment where possible according to Spencer, Bishop, Dawson, and Goodman [10]. Field tests were also taken away from the coaching program to avoid conflicts of interest and to reduce the effect of circadian variations; testing sessions were performed at the same time of day. In addition, we ensured that all participants were within the same region as using teams from other regions would not have been comparable in aspects such as club level, governance and administration, financing and sponsorship, technical bench setup, and availability of qualified medical officers and paramedics, sporting infrastructure and geographical location.

2.3. Timing of Testing

It is apparent that the emphasis on fitness testing is more common during pre-season, when physical preparations for the upcoming competitive season are the key. Barnes, Hopkins, McGuigan, and Kilding stated that during the season when the focus is more towards regeneration and match preparation, time for physical fitness tests may be limited. However, regular testing between and within seasons has utility in identifying specific areas of physical fitness that may need attention [11]. These study sites were chosen because of their availability during the Covid-19 pandemic.

2.4. Data Collection Tools and Procedure

Data collection was conducted using the Footeval test. The protocol is designed to reproduce the requirements of football as much as possible. The first step was designed as a warm-up and lasted two minutes. All other steps lasted one minute followed by a recovery phase of thirty seconds, and for each step in this test, the intensity was set by speed in km/h. The first level started at 6.5km/h and the intensity was increased by 0.5 km/h between each workout phase [5].

To ensure players accurately followed the intensity increases, a specific soundtrack was played to provide audio feedback to the players, allowing them to adjust their speed at each extremity of the test area (20m). A single beep signaled the beginning or intermediate positions in the step, while a double beep indicated the end of the workout. The test was over when the subject was no longer able to maintain the intensity indicated by the audio beep. If the player was more than 3 meters from the line, and not able to reduce the gap, we considered that the test was over. The test was also considered to have ended when the player was not able to restart a workout session after the recovery phase.

Furthermore, the player was stopped if he made more than 2 technical errors within a step considering bad passes, bad shots, or bad ball control as technical errors. Each session was preceded by a period of rest of 7 days (for baseline, mid, and post-test) and to standardize the test, it was carried out on the same field when the weather was favorable (no wind or rain) with temperatures between 25 and 28°C. The participants were asked to give feedback on whether the instructions of the material organization and the test itself were clear, simple, and easy to follow. Four (n=4) participants gave suggestions for adjustments to the protocol and all rest (n=6) reported instructions to be clear and easy to follow. The practical considerations which needed attention included the use of portable barriers for reflecting the kicked ball, audio track, and audio player under the equipment required was replaced by a physical football player, verbal commands, and a referee's whistle respectively.

The idea was to have a true practical picture and experience of the drill as seen in the actual football match and this was implemented in the main study. Moreover, the questioner did not need any revision as it was applied as suggested by the test instructions to which participants of the study responded adequately.

2.5. Statistical Analysis

To compare the significant differences of aerobic endurance levels amongst the football teams, the data was analyzed and compared using STATA Version 13. Pre-test, mid-test, and post-test data was measured on the amount of resting heart rate (RHR) and maximum heart rate (MHR) and maximum oxygen uptake (VO_{2max}). The differences between the mid-test and post-test scores of the variables were subjected to statistical analysis using One-way analysis (ANOVA) to test the difference among means of more than two independent groups for one independent variable (with more than one level). The advantage was that the ANOVA examined the influence of an independent variable on a dependent variable at p-value of 0.05 while removing the effect of the covariate factor by first conducting a regression of the independent variable (i.e., the covariate) on the dependent variable.

3. Results

3.1. Participants' Demographic Description

Table 1 indicated that thirty-six (36) male participants took part in this study with mean age, height, and body mass at 22.2 years, 1.70m, and 68.4kg, respectively. Majority (77.7%) had completed secondary school and 44.4% had at least 1-2 years of professional experience.

Table 1. *Participants' demographic description.*

Variable	Frequency	Standard deviation (±)	Percentage (%)
Age at last birthday			
18-21	8		22.2
22-24	9	22.2±	25
25-27	8		22.2
28-30	5		13.8
Play position			
Goal keepers	4	-	11.1
Defenders	12	-	33.3
Midfielders	12	-	33.3
Forwards	8	-	23.2
Subject characteristics			
Height (m)	-	1.70±	-
Body mass (kg)	-	68.4±	-
Years of professional experience			
1-2	16	-	44.4
3-4	14	-	38.8
5-6	6	-	16.6
7-8	-	-	-
Qualifications			
Certificate (Grade 12)	28	-	77.7
Diploma	8	-	22.2
Bachelor's Degree	-	-	-
Master's Degree	-	-	-

3.2. Participants Average (±sd) Age, Height, and Body Mass at Different Team Play Positions

Table 2 shows that the average (±sd) age for all participants was 22.2±, height 1.70±, and body mass at 68.4± respectively of players at different team play positions.

Table 2. *Average (±sd) age, height, and body mass at different team play positions.*

Subject characteristics				
Subject	**N**	**Age (years)**	**Height (m)**	**Body mass (kg)**
Whole population	10	22.2±	1.70±	68.4±
Goal keepers (GK)	1	23±	1.80±	75±
Defenders (B)	3	20±	1.75±	75.3±
Midfielders (MF)	3	23.3±	1.70±	68±
Forwards (F)	3	23±	1.63±	63.6±

3.3. Participants Baseline Resting Heart Rate (RHR) and Maximum Heart Rate (MHR) Recorded at Different Play Positions

Figure 1 show the baseline resting heart rate (RHR) and maximum heart rate (MHR) recorded at different play positions for the participants ranged from 42-60 bmin and 178-188 bmin, respectively, with average RHR at 49 bmin and MHR at 182 bmin.

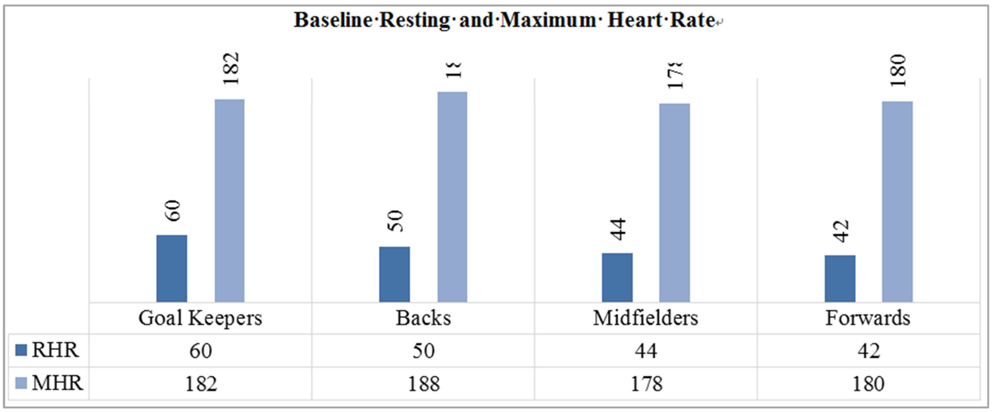

Figure 1. *Baseline Resting heart rate (RHR) and Maximum heart rate (MHR) recorded at different play positions.*

3.4. Participants Baseline VO_{2max} Recorded at Different Play Positions

Figure 2 shows the baseline VO_{2max} for the participants which ranged from 45.5-64.28ml/kg/min at different play positions. The average VO_{2max} was recorded at 56.715mi/kg/min with goalkeepers recording at 45.5ml/kg/min and strikers (F) recording the highest at 64.28ml/kg/min.

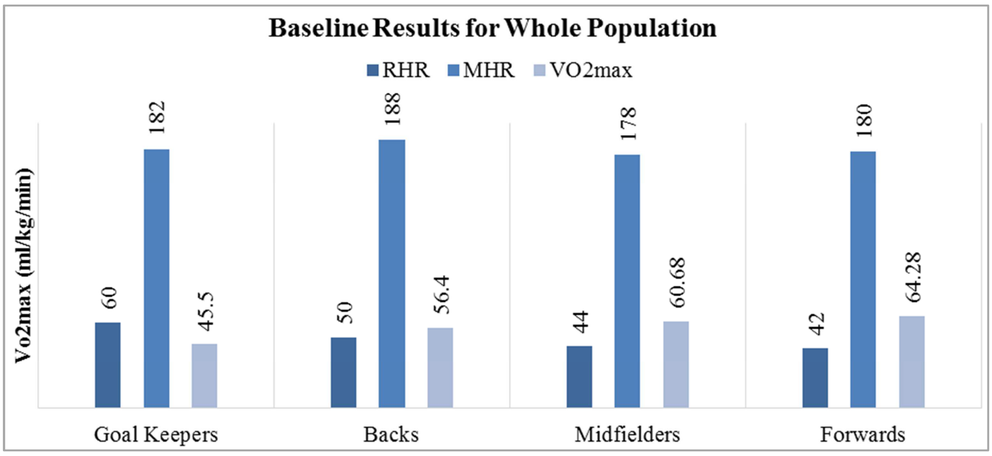

Figure 2. *Baseline VO_{2max} recorded at different play positions.*

3.5. Mid-Test Resting Heart Rate (RHR), Maximum Heart Rate (MHR) and VO_{2max} Recorded at Different Play Positions

The mid-test average VO_{2Max} uptake was recorded at 58.65ml/kg/min, RHR at 52 bmin, and MHR at 182 bmin for mid-test results for all participants. The goalkeepers had a higher RHR with 57 bmin, followed by full backs with 52 bmin; midfielders had 48 bmin and forwards 44 bmin. For MHR, full backs had 188 bmin; goalkeepers had 182 bmin, forwards with 180 bmin, and midfielders with 178 bmin (Figure 3).

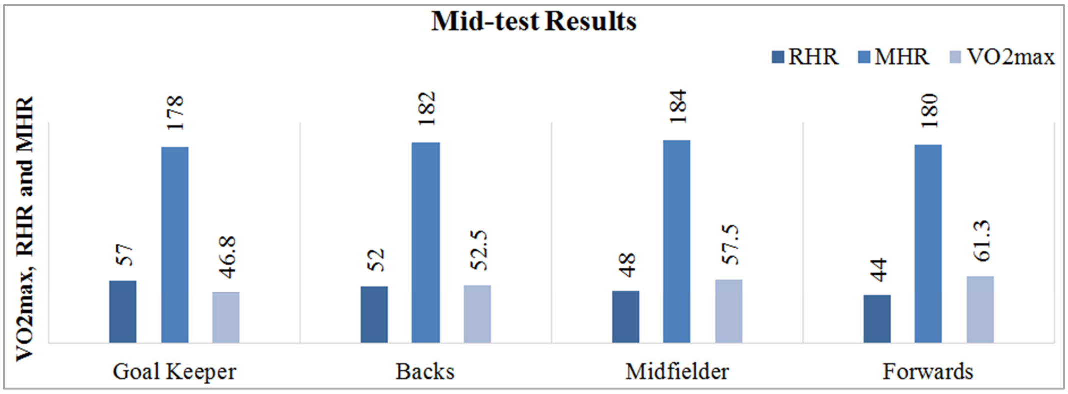

Figure 3. *Mid-test resting heart rate (RHR), maximum heart rate (MHR) and VO_{2max} recorded at different play positions.*

3.6. Post-Test RHR, MHR and VO_{2max} Results Recorded at Different Play Positions

The posttest average VO_{2max} uptake was recorded at 61.5ml/kg/min, RHR at 63 bmin, and MHR at 180 bmin for baseline results for all participants. In the post-test, midfielders had the highest RHR with 60.2 bmin, closely followed by the goalkeepers with 60 bmin; backs had 52 bmin, and forwards had 46 bmin. For MHR, forwards had 188 bmin, midfielders had 184 bmin, while backs had 180 bmin, and goalkeepers recorded 178 bmin (Figure 4).

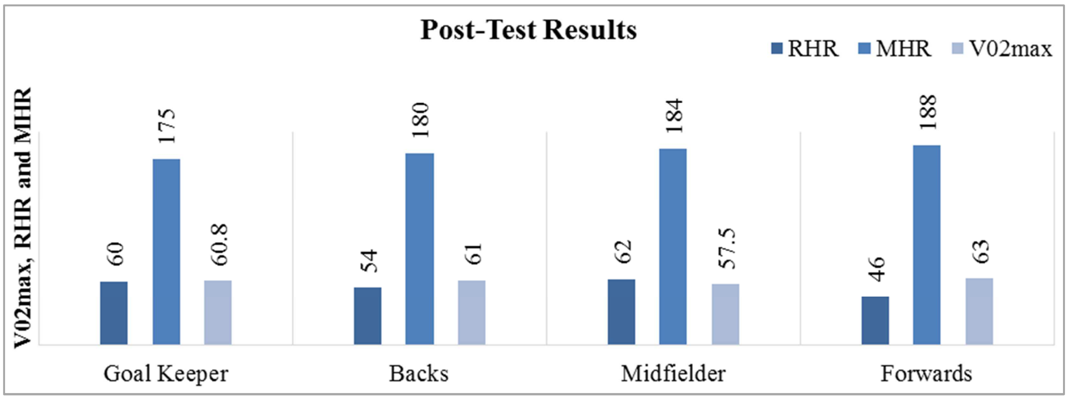

Figure 4. *Post-test RHR, MHR and VO_{2max} results recorded at different play positions.*

3.7. Association Between the Age of the Players and the VO_{2max} R^2 0.84

The study showed an association between the age of the players and the VO_{2max} R^2 0.84 at a p-value of 0.03 (Table 3).

Table 3. *Age and VO_{2max} p-value.*

Age and VO_{2max}			
Age (years)	**Number**	**VO_{2max}**	**P-value**
18-21	8	62.8	
22-24	9	62.1	0.03
25-27	8	57.7	
28-30	5	54.6	

Position and VO_{2max}			
Positions	**Number**	**VO_{2max}**	**P-value**
Goal keepers	4	58.4	
Defenders (B)	12	57.4	0.07
Midfielders (MF)	12	63.7	
Forwards (F)	8	61.5	

4. Discussion

The present study investigated the level of aerobic endurance using the Footeval test among elite football players in Lusaka, Zambia who participated in the 2021/2022 national league season. From the outcomes, it was observed that the volume of oxygen uptake gradually increased from the baseline to mid and all the way to post-test at different play positions. The results are in agreement with the studies conducted by Mackenzie et al and Pye & Miller [12 and 4] which came to the same conclusions and discovered that you can boost your VO_{2max} by working out for at least 20 minutes, three to five times a week, at an intensity that causes your heart rate to climb to between 65 and 85% of its maximum [10 and 11]. Average team maximum oxygen uptake obtained among male elite football players in this study was 61.5ml/kg/min. Stølen, K, Castagna, & Wisløff reported a slightly higher VO_{2max} from tests on elite male teams in an international comparison (teams in the highest division or national teams) which averaged approximately 61 ml/kg/min [13]. At roughly 84% of VO_{2max} the study's anaerobic threshold was reached. Vanfraechem & Tomas and Al-Hazzaa, K. S, S. A & Sulaiman M. A. reported that this is a little higher value than the elite teams' results, which indicate an average value of roughly 82% of the ventilator anaerobic threshold in an international comparison [14]. Similarly, Ströyer, Hansen, & Klausen showed that age-related losses in VO_{2max} results from reductions in maximal heart rate, stroke volume, and maximal arterio-venous O_2 difference [15]. The mechanism behind this, however, is not easily explicable due to several confounding variables, including the lungs' ability to diffuse air, vascular conductance, the density and activity of the mitochondria in skeletal muscle mass, and training volume. Bloomfield, Polman, & O'Donoghue also reported that one might expect that players in different play positions may differ in aerobic and anaerobic power due to different work demands related to their position [16]. This is the rationale behind the present comparison of play positions. Small to moderate differences in VO_{2max} according to playing position were observed in the investigation. Mid-fielders scored the highest mean VO_{2max} values, ahead of forward, goalkeepers, and then defenders, in that order although Reilly & Thomas stated that internal ranking by player position is not in accordance with their findings [17]. For instance, central defenders had the poorest VO_{2max} recorded at 57.4ml/kg/min among outfield players, while fullbacks and midfielders scored the best VO_{2max} values In our playing position categorization was somewhat limited, but we observed that midfielders, who typically covered the longest distances during games, had somewhat higher VO_{2max} recorded at 63.7mm/kg/min.

The present investigation compares the physical performance of elite football players in different team play positions. The results of this comparison can be used in the ongoing debate about the need for differentiation in physical capacity between team play positions. The comparison of average values concerning VO_{2max} showed no significant differences between team positions (defender, midfielder, and attacker) but a somewhat increase with the younger age group between 18-24 years of age recording 62.1-62.8 VO_{2max} respectively, [6, 10]. Furthermore, the absence of physical profiles concerning the above parameters among players in different team positions may have an impact on monitoring the team's physical fitness hence affecting performance.

5. Conclusion

This study demonstrates that maximal oxygen uptake (VO_{2max}) is one of the most important physiological parameters that can describe the amount of work carried out during a soccer match and is most effectively trained at an intensity of 90-95% of the maximum heart rate normally by combination of running and other tactical skills. Further, the average VO_{2max} among players participating in the National League in Lusaka province was 61.5ml/kg/min with the younger age groups recording a higher VO_{2max} at 62.8ml/kg/min compared to the older age group at 54.6ml/kg/min. There was some significant difference (p-value of 0.03) in VO_{2max} at different age groups but no significant difference in VO_{2max} at different play positions. This outcome suggests that using the Footeval test and specifically designed training elements, soccer players who are readily motivated by playing with the ball, may no longer need to carry out plain running to improve their maximal oxygen uptake hence improving performance.

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